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# SCHOOL SCIENCE AND MATHEMATICS

JANUARY 1959

# School Science and Mathematics

*A Journal for All Science and Mathematics Teachers*

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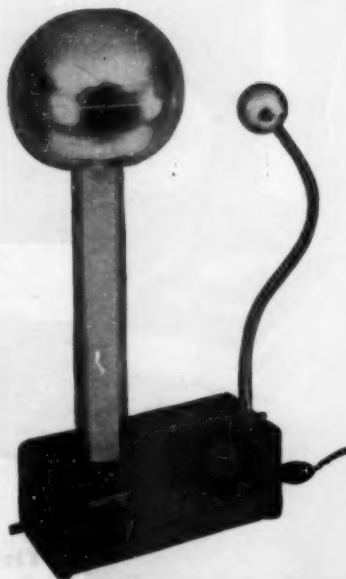
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# SCHOOL SCIENCE AND MATHEMATICS

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VOL. LIX

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## Sputniks and High School Mathematics

Kenneth P. Kidd

*University of Florida, Gainesville, Florida*

Since October 4, 1957, moon-watching, a pastime of romantic youth, has taken on irresistible appeal for countless thousands of serious and unromantic minded people the world over. It was on that day that Sputnik, the first man-made moon, was made to circle the earth. Many questions and much speculation are on the lips of thinking men everywhere.

But what has Sputnik to do with mathematics? The answer is simply this: Mathematics is a language of abstract symbols that is the cornerstone of science and of our technological society. A study of the movement and masses of heavenly bodies must involve the mathematics of arithmetic, algebra, geometry, and calculus. All works on astronomy or space travel must either be of a mathematical nature or must be based on results, themselves determined through mathematical calculations.

Many aspects of astronomy hold a great fascination for many high school students. For this reason the Sputniks offer a challenge to mathematics teachers to give meaning and significance to many mathematical concepts. The purpose of this discussion is to show how the following ideas of high school mathematics can be brought into an analysis of some of the simpler questions about satellite movements: (1) variable, (2) constant, (3) variation, (4) ellipse, (5) scientific notation, (6) square and cube roots, and (7) arithmetical computation. Students who have learned to use the slide rule should be encouraged to use it in their computations.

Countless millions of bodies are moving through space. The movement of all of these is influenced by three forces:

1. the force of *mutual attraction* ( $F_A$ ) between all objects,
2. the force of *inertia* ( $F_I$ ) that describes the tendency for an object to move in a straight line at a constant speed, and
3. the force due to collision with objects.

Let us direct our attention to the first two forces. Consider an object,  $P$ , having a small mass and traveling in the vicinity of an

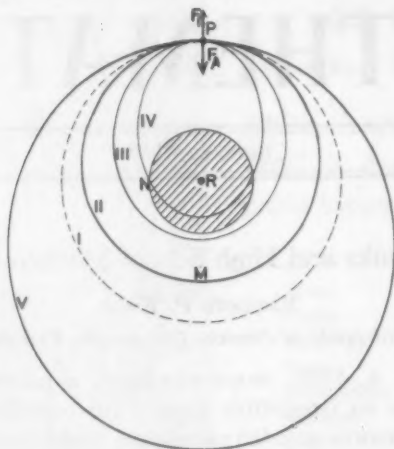


FIG. 1

object,  $R$ , with a large mass (Figure 1). Vector  $F_A$  represents the force of attraction between the two objects—a force, so to speak, pulling  $P$  off of its straight line path and toward  $R$ . The force of inertia, represented by vector  $F_I$ , is that force exerted on  $P$  tending to keep its motion in a straight line. Let us examine the mathematical statements relative to the magnitudes of these two forces:

$$F_I = \frac{m_1 V^2}{S} \quad (1) \quad F_A = \frac{G m_1 m_2}{S^2} \quad (2)$$

$m_1$  = mass of object  $P$  (earth satellite, for example).

$m_2$  = mass of object  $R$  (earth, for example).

$V$  = orbital velocity of  $P$ .

$S$  = distance between the centers of mass of  $P$  and  $R$ .

$G$  = universal gravitational constant.

To demonstrate formula (1) in the classroom, tie the end of a piece of strong twine to a lead weight with mass  $m_1$ . Hold the twine a fixed distance,  $S$ , from the weight and swing in a circular orbit at a velocity  $v$ . The pull on the hand that is noticed is equal to the force  $F_I$ . Change

the velocity and observe the corresponding change that takes place in  $F_I$ . Have students observe that one of the letter symbols,  $v$ , was arbitrarily given different values. For this reason we speak of this letter symbol as an independent variable. The letter symbol  $F_I$  assumed consequent values as  $v$  was given its series of values;  $F_I$ , then, is a dependent variable. One might write formula (1) on the chalkboard using two colors of chalk—one for the constants and the other for the variables. In interpreting the formula one might say that the inertial force  $F_I$  of an object moving in a circular path varies directly as the square of its orbital velocity.

Similarly, one might prescribe conditions for a demonstration in such a way as to have a different choice of constants and variables. Letter symbols in a formula may be considered constants in certain conditions and variables under other conditions. In our discussion of the Sputniks,  $m_1$  will be considered a constant and the other 3 letter symbols as variables because the mass of a Sputnik may be considered as constant while its velocity and its distance from the center of the earth changes.

Formula (2) is the mathematical expression for the universal law of gravitation which is often stated as:

*Each particle of matter attracts every other particle with a force which is directly proportioned to the product of their masses and inversely proportioned to the square of the distance between them.*

In a classroom demonstration of formula (2), letter symbols  $G$ ,  $S$  and  $V$  may be considered as constants. The only variables that one can easily demonstrate are  $F_A$  and  $m_1$ . To do this simply fasten a container to a rubber band. Pour in a cup of water and notice the pull,  $F_A$ , on the rubber band. Pour in another cup and observe how the pull has increased. The mass of the container and its contents is represented by  $m_1$ .  $F_A$  is directly proportional to  $m_1$ .

Let us think of  $P$ 's movement in Figure 1 as being perpendicular to a line connecting the centers of mass (centroids) of  $P$  and  $R$ . If  $F_I = F_A$ ,  $P$  will move in a circular path (I) around the center of gravity or centroid of  $R$ . In order to do so,  $P$  must have an orbital velocity of sufficient magnitude to produce  $F_I$ , that will counterbalance the attraction toward  $R$ .

Since  $F_I = F_A$ , a formula for the velocity of  $P$  may be obtained from equations (1) and (2). This equation may be stated as

$$V = \sqrt{\frac{Gm_2}{S}} \quad (3)$$

Since  $G$  and  $m_2$  are constants, equation (3) expresses the relationship between the satellite's velocity and its distance,  $S$ , from the center of the earth. This is an example of  $v$  varying inversely as the square root of the distance. For example, the moon, which is approximately 240,000 miles away from the earth, has an orbital velocity of only about 2,300 miles per hour, while Sputnik being much nearer has an average velocity of almost 18,000 miles per hour. Formula (3) assumes that  $P$  is under the gravitational influence of no other body. The sun, however, does exert noticeable influence upon the moon, thereby necessitating the use of a more complicated equation than (3).

If  $P$  has an orbital velocity greater or less than the amount required from formula (3), then  $F_I$  and  $F_A$  will not be in balance and  $P$  will not travel on a circular orbit having the center of gravity of  $R$  at a focus. Suppose the velocity of  $P$  at its position in Figure 1 is less than that determined from (3).  $F_I$  will then be less than  $F_A$  and  $P$  will "fall into" or toward  $R$ . This falling will be on an elliptical orbit, such as II. As it moves, you will notice that it is getting closer to  $R$ . It is also increasing its velocity and value of  $F_I$ . Sometime prior to Point  $M$ ,  $F_I$  becomes equal to and then greater than  $F_A$ , causing  $P$  to come out of its fall.  $P$  reaches its closest point to  $R$  at some point  $M$ .  $M$  is also the point of  $P$ 's greatest velocity and greatest inertial force. Since  $F_I > F_A$  at  $M$ ,  $P$  begins to fall away from  $R$  as it moves past  $M$ , decreasing its speed and also  $F_I$  as it does.

If the velocity of  $P$  at its position in Figure 1 is less than that in the previous paragraph the orbit, III, will be more greatly elongated and will approach even nearer to  $R$ . Taking another example of still smaller orbital velocity for  $P$ , orbit IV might describe the path. Orbit IV, as well as III and II would be elliptical about the centroid of  $R$ . But orbit IV intersects the surface of  $R$  at  $N$ .

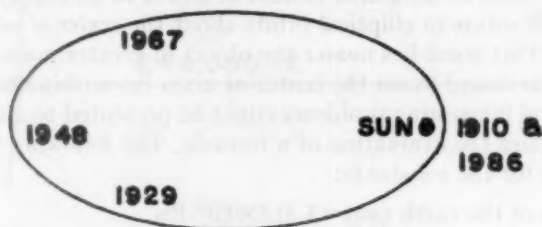
If the velocity of  $P$  happened to be greater than that required by formula (3),  $F_I$  would be greater than  $F_A$  and  $P$  would "fall away" from  $R$  and take an elliptical orbit such as V. If  $P$  has a sufficient velocity it would escape from the gravitational attraction of the earth forever.

It might be said that the Russians were able to impart to Sputnik I an orbital velocity at point  $P$  very near that specified by formula (3), for its orbit is almost circular. The perigee (minimum) height of Sputnik I was about 150 miles, while its apogee (maximum) height was about 550 miles from the earth. For Sputnik II, on the other hand, these heights were 150 miles and 1,000 miles respectively.

There are countless groups of bodies in space revolving around each other in elliptical orbits. For example, the planets form a group of satellites revolving around the sun. The moon, Sputniks and prob-

ably millions of small particles too small to be seen, are satellites of the earth. Other planets are known to have satellites of their own.

Some of the elliptical paths are almost circles, while others are greatly elongated. The path of the earth about the sun is almost circular. The orbit of Halley's Comet is an example of an elongated ellipse (Figure 2), requiring 76 years for the comet to make the



**ELLIPTICAL ORBIT OF HALLEY'S  
COMET**

FIG. 2

journey. In the case of circular orbits, the orbital velocity of the satellite is constant. In the case of the elongated ellipse the orbital velocity of the satellite varies greatly, being greatest when the satellite is nearest the attracting body.

What can we expect to happen to the Sputniks? They were sent aloft with sufficient horizontal velocity so that their inertial forces counter-balanced the earth's gravitational pull. The Sputniks, therefore, are weightless with respect to the force of gravity. They will continue to move on their orbits until other forces intervene, such as collision with meteorites and air particles. That air particles are present at 150 miles is shown by the fact that the orbit of Sputnik I began to spiral slowly downward toward the earth immediately after it was launched. Consider Sputnik's I orbit as being similar to orbit II in Figure 1.  $M$  is the point of greatest atmosphere density on the orbit and also the point of greatest speed because it is the perigee height. In fact, observations showed that shortly after the launching the velocity of Sputnik I was 10 per cent greater at the perigee ( $M$ ) than at the apogee ( $P$ ). The slowing of the satellite will be greatest along the orbit at  $M$ . And instead of "falling away" from the earth after  $M$ , to the extent shown by orbit II,  $P$  will tend to approach more nearly a circular path. The net result is that the orbits of the Sputniks will eventually become circular getting closer to the earth at each successive orbiting. The circular orbits will then reduce in size in a spiral fashion slowly at first, then with greater speed until the satel-

lites finally burst into flames due to friction with air particles in the denser air nearer the earth's surface. By accurately measuring the rate at which the Sputniks are "falling" toward the earth, scientists can make judgments relative to the density of the air at various heights.

In our discussion the object  $P$  has been considered to be of insignificant mass as compared to that of object  $R$ . In reality the two objects will rotate in elliptical orbits about the *center of mass of the two objects*. This point lies nearer the object of greater mass—in the case of the earth and moon the center of mass lies within the earth itself.

Several interesting problems might be presented to students which will require the evaluation of a formula. The following values might be used for the constants:

Mass of the earth ( $m_2$ ) =  $1.312 \times 10^{25}$  lbs.

Mass of the moon is =  $1.608 \times 10^{23}$  lbs.

Radius of the earth is 3960 miles.

Value of  $G$ :  $9.62 \times 10^{-14}$ , when  $V$  is considered in miles per hour and  $S$  in miles.

It has been suggested that a satellite equipped with solar batteries and television relay equipment be launched from the earth to a height that would enable it to circle the earth from west to east in 24 hours. Since the earth is revolving each 24 hours, this satellite would stay above one spot along the equator. With four or five of these spaced along the equator, one could cover the world's surface except for polar regions with television signals.

At what distance must the orbit be located from the earth? Let  $S$  represent the distance from the center of the earth in miles.

$$V = \frac{\text{orbital distance}}{24 \text{ hours}} = \frac{2\pi S}{24}; \quad V = \sqrt{\frac{Gm_2}{S}}$$

Equating the two equations and solving for  $S$  we obtain a distance of 26,200 miles from the center of the earth.

The earth is spinning around once every 24 hours. Any spot on the equator is moving at the rate of about 1,035 miles per hour. As the earth turns, all objects on the earth's surface are acted upon by a force of attraction directed toward the center of the earth and a much smaller inertial force (because of the earth's rotation) away from the center of earth. Now, if the earth rotated at a much higher velocity the inertial force would become greater. At what velocity must the earth rotate in order that an object at the equator would be weightless with respect to earth's gravitational force and be free to leave the earth?

An object may soon be sent to the moon. At what distance from the moon will the gravitational pull of the moon be equal to that of the earth? Solve for  $X$ :

$$\frac{Gm_1 \times 1.608 \times 10^{22}}{X^2} = \frac{Gm_1 \times 1.312 \times 10^{25}}{(240,000 - x)^2}$$

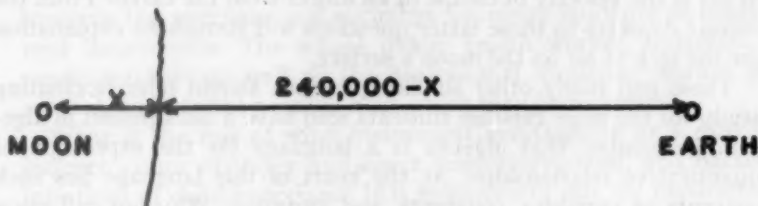


FIG. 3

At what upward (directly away from earth's center) velocity must an object be fired from the earth in order to reach a particular height? A formula may be obtained from the statement that the object must have enough kinetic energy to overcome the gravitational pull of the earth. Kinetic energy is given by the formula  $E_k = \frac{1}{2}m_1v_2$ . Remembering that the gravitation pull of the earth varies inversely as the square of the distance from the center of mass of the earth, the total gravitational pull to be overcome may be found by integrating

$$\int G \frac{m_1m_2}{S^2} ds$$

between the point of release of object and point at which the object would be under a greater attraction from other heavenly bodies than from the earth itself. From

$$\frac{1}{2} m_1 V^2 = Gm_1m_2 \int_{S_0}^{S_1} \frac{dS}{S^2}$$

we may obtain

$$V^2 = 2Gm_2 \left[ \frac{1}{S_0} - \frac{1}{S_1} \right],$$

where  $S_0$  is the number of miles from the center of mass of the earth to the point where the final force has been applied to the object, and  $S_1$  is the number of miles to the point at which the object would no longer be "pulled" toward the earth. Observe that no account has been taken of the effect of air friction. Since  $S_1$  would be very much larger than  $S_0$ , for a close approximation we may consider  $S_1$  to be negligible and find that

$$V = \sqrt{\frac{2Gm_2}{S_0}}$$

What velocity was given to an Air Force rocket fired on October 22, 1957 from balloons at a height of 20 miles from the earth's surface if the altitude reached was "more than 4,000 miles" into space? What is the velocity of escape of an object from the earth? From the moon? Answers to these latter questions will furnish an explanation for the lack of air on the moon's surface.

These and many other similar questions should offer fascinating study for the more capable students who have a background in algebra. Remember that algebra is a language for the expression of quantitative relationships. At the heart of this language lies such concepts as variables, constants, and variation. Why not call upon the Sputniks to help students give meaning to and see the applications of these concepts?

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#### REFRIGERATION GASES MAY SOLVE MISSILE LUBRICATION PROBLEM

The chemical that cools the housewife's refrigerator may help solve a major high-temperature lubricating problem in missile and aircraft development.

Several gases of the Freon family, a widely-used refrigerant, have been found to lubricate some metal alloys at temperatures up to 1,200 degrees Fahrenheit.

The gases combine chemically with the metal to be lubricated and form a film that reduces friction. However, not all Freon gases will react in such a way with all metals.

One of the gases is an effective lubricant for certain steels at lower temperatures, but above 600 degrees the metal was corroded. In view of the corrosive action, research has been turned to the use of nickel and cobalt alloys. It has been found that gases containing bromine atoms were more effective with nickel alloys, and gases containing chlorine had superior lubrication properties with cobalt alloys.

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#### SUMMER FELLOWSHIPS

Purdue University announces the seventh annual all expense General Electric Summer Fellowship Program in mathematics for junior and senior high school teachers from June 22 through August 1, 1959. Courses in the program carry graduate credit. Eight semester hours may be earned. Any secondary school teacher of mathematics who teaches in Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio, Tennessee, West Virginia, Wisconsin, has a bachelor's degree, has had differential and integral calculus, and has not previously held a General Electric Summer Fellowship in Mathematics or Science is eligible.

This program is sponsored by the General Electric Educational and Charitable Fund in cooperation with the Department of Mathematics and Statistics. Further information and application forms may be obtained by writing

GENERAL ELECTRIC SUMMER FELLOWSHIP PROGRAM  
Department of Mathematics and Statistics  
Purdue University  
Lafayette, Indiana

## School Band Wind Instrument Mouthpieces May Harbor Countless Disease Germs\*

Arthur H. Bryan

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Nearly all schools sponsor some sort of an orchestra or band which involves the purchase and exchange by many students of brass or reed instruments. The school public health worker, hygienist, or music teacher—as well as the professional musician—should give some thought to the possible risks which may be incurred.

What is the role of wind instrument mouthpieces as a direct or indirect vector of upper and lower respiratory, viral, and bacterial infections of child musicians? Is it hygienically safe for musicians or students to play each other's instruments? Is it important that mouthpieces be cleansed regularly? Can these mouthpieces be foci of reinfection?

Do brass and reed mouthpieces need some kind of sterilization? Nurses and doctors, as a necessary hygienic measure, keep thermometers in alcohol, and rinse them in an antiseptic solution before using them in the patient's mouth. Housewives, too, rinse their dishes in hot water in order to sterilize them, but most players of wind instruments are very careless in these matters.

In previous research, the author has made some extensive studies of lip, teeth, and mouth bacteria. The mouth harbors literally millions of micro-organisms, mostly thermolabile micrococci, including *Streptococcus hemolyticus*, *Staphylococcus aureus*, *albus*, and *citreus*, many types of pneumococci, the pneumobacillus, *Spironema vicenti*, and the fusiform bacillus, the T.B. bacilli, *H. influenza*, *N. intracellularis*, the viruses of cold, influenza, virus V, virus pneumonia, and possibly the virus of infectious mononucleosis. Most of the organisms are avirulent harmless commensalists, and rarely pathogenic. If, however, the resistance of the body is lowered (Disease=Virulence/Resistance), these organisms may become pathogenic (disease inciting) secondary invaders and, together with specific viruses, be transmitted as a droplet or as oral communicable disease infections.

The brass cup mouthpieces come directly in contact with the musician's moist lips, mucus, or saliva, which may harbor thousands of micro-organisms. The reed instrument is held for long periods of time in the musician's mouth and may pick up millions of oral bacteria. These in turn can reinfect an individual playing the instrument if hygienic measures are not previously carried out by sterilizing or, at

\* Report of a Biological Science Student Project.

least, cleaning the mouthpiece regularly. If days or weeks go by without cleaning the mouthpiece, saliva mixed with food particles, detritus, sputum, and mucus becomes a natural culture medium capable of reproducing millions of undesirable microbes.

#### PROCEDURE OF THE EXPERIMENTS

(1) Brass and reed sections of public school bands and orchestras were brought into the Bacteriology Laboratory for testing their instrument mouthpieces.

(2) The last time these mouthpieces were used and cleaned was recorded.

(3) Each mouthpiece was identified, and thoroughly rinsed in 150 cc. of sterile water for one minute to wash out the microbial flora and oral detritus.

(4) Two cc. of this thoroughly shaken wash water was plated on nutrient or blood agar plates and incubated at room temperature for 24, 48, and 72 hours. Comparative readings were made at all three periods.

(5) Plate and differential counts were made and the possible pathogens identified with stained slides and by subculturing suspicious colonies on differential media.

(6) The same wind instrument mouthpieces were later washed in

- (a) cold or hot soapy water,
- (b) alcohol,
- (c) weak hypochlorous acid, in 1:500, 1:1000, 1:10,000, 1:50,000, and 1:100,000 dilutions,
- (d) lysol 1:200, 1:500,
- (e) bactine solutions,
- (f) boiling water for 10-20-30 minutes for the brass cup mouthpieces

The same technique was repeated as in pre-cleaning tests. The plates were compared before and after washing with antiseptics. Final differential counts were also compared and charted for quick comparative data recapitulation.

#### RESULTS

(1) Reed instruments harbor millions of possible pathogenic micrococci, with the numbers, generally, directly proportional to the recency of cleansing or disinfecting.

(2) The smallest reed instrument mouthpieces, such as oboe, bassoon, clarinet, and saxophone, harbored the greatest number of microbes; often too numerous for an accurate colony count.

(3) The tuba, trombone, French horn, and coronet contained the fewest numbers of microbes. Bacterial counts in the brass mouthpieces also varied directly with the lapse of cleaning.

(4) In some unhygienic individuals, the instrument mouthpieces

harbored so many millions of microorganisms that only approximate numerical estimates were possible using professional colony counters.

(5) A clarinet mouthpiece in daily use without cleansing for two or three weeks harbored over 9,000,000 micrococci, 3,000,000 hemolytic and the balance non-hemolytics as possible pathogens.

(6) The identifiable micrococci were largely hemolytic streptococcus viridans, and undifferentiated, untyped pneumococci, the Friedlander bacillus, and *H. influenzae*. The *M. tuberculosis* and the *Spironema vincenti* (cause of trench mouth) were identified as occasional invaders.

(7) The oral detritus in smelly mouthpieces harbored literally millions of possible pathogens (disease inciting micro-organisms) as foci of infection for infecting the user.

(8) Persons suffering from trench mouth (Vincent's angina) may directly infect their instruments with the causative bacteris. Here special antiseptic precautions are advised, to prevent dissemination of the disease.

(9) Students who washed or sterilized their brass mouthpieces in hot soapy water daily, reduced the bacterial count to a comparatively few air microbes and relatively fewer micrococci.

(10) Boiling brass instrument mouthpieces for 20-30 minutes sterilized them completely, or reduced the microbial flora to negligible number.

(11) By way of comparison, a clarinet mouthpiece washed daily or soaked in chlorine solution reduced counts to less than 30,000.

(12) The reed instruments need special prophylactic attention, for the reeds themselves are damaged by boiling or by using soapy water. Cold soapy water alone had little effect on lowering the incidence of the microbial flora.

(13) Reed instrument mouthpieces rinsed for 10 minutes in various dilutions of hypochlorous acid, which liberates nascent chlorine, reduce microbial counts to as low as 30,000 per 150 cc. of wash water.

(14) Sporulating, decay, and putrefactive bacilli and heterogeneous molds are constant invaders of the unwashed mouthpiece of reed instruments. They account for many of the proteolytic, putrefactive odors commonly encountered in unclean instruments.

#### OBSERVATIONS

The 5 parts per million hypochlorous acid, the weakest strength tested, required two hours before the reeds were comparatively germ free. Twenty-four hour immersion in any of the antiseptics tested apparently did not injure materially the vibratory movements of the reeds. Musicians played them afterward. If the reeds were soaked in any of the twenty odd antiseptics for only half an hour, and washed

in warm water to remove the antiseptic, and finally dried immediately, the reeds (both wood and plastic) were not injured by the treatment.

The mouthpieces minus the reeds were rendered practically sterile by immersion for half an hour in any of the antiseptics tested. Brasses need only boiling for 20 minutes or immersion in any antiseptic solution to render them virtually sterile. However a few harmless spore bearing spreader colonies of the air flora survived, but these have no public health significance. Any antiseptics on the market, suitable for use on wind instruments, will give germicidal coefficients as indicated in their circulars. Because all these antiseptics are subject to government foods and drugs assay, they can be relied on.

#### CONCLUSIONS

(1) Mouthpieces heavily infected with bacteria and viruses can be hazardous to persons using the wind instruments because they are a possible vector of oral communicable diseases, or respiratory infections such as colds, influenza, pneumonia, tuberculosis, Herpes fibrillis (cold sores, fever blisters), and possibly rare diseases these days such as scarlet fever, streptococcic sore throat, diphtheria, epidemic meningitis, and the Dental disease "Trench Mouth."

(2) Foul smelling, contaminated mouthpieces may be a means of reinfection to the user.

(3) Exchange of instruments without previous sterilizing by boiling or antiseptic treatment is more than calculated risk; *it is a definite health hazard.*

(4) Mouthpieces of music instruments may harbor literally millions of possible pathogenic bacteria, putrefactive micro-organisms, and possibly some multiple virus strains indigenous to the respiratory tract. These may grow on the moist sputa, saliva, and decomposed food particles. *School health authorities should therefore insist on the simple sterilization of brass instrument mouthpieces before exchange or use as a hygienic necessity.* Safe oxidizing antiseptics which are not injurious to reeds, should be used to cleanse or soak mouthpieces, and joints.

(5) All musical instrument mouthpieces and joints as a minimum requirement should be cleansed with ivory or possibly tincture of green soap and water, used regularly to keep down the microbial count, and possible virus infections (hot for brasses and cold for reeds). The mouthpieces should also be preferably kept covered when not in use. Ethyl alcohol works fine on brass mouthpieces in storage, just like the doctor's thermometer.

(6) Microbial flora need moisture and food. Drying the mouth pieces in warm air ovens or in bone dry rooms stops the reproduc-

tion of the organisms, thus arresting their growth. However, when food particles with moist sputa and saliva later enter the mouthpieces, many of these dormant organisms may be revived, and start a new life cycle. Twenty-four hours drying will arrest the growth and reduce the virulence of most microbes.

(7) Many bacteria collect in the brown slime in sections of wind instruments. Therefore, connecting parts which are slimy should obviously be washed, cleansed, or given a mild antiseptic treatment.

(8) The chamois swabs or cleaners which are used to wipe out instrument sections and mouthpieces, if not washed out or kept in an antiseptic solution, can be as heavily infected as the mouthpieces themselves. The swabs should be kept soaked in alcohol, or clorox, 1:1,000-1:10,000, or any other good colorless, oxidizing antiseptic. If cloth is used as the contact agent in the cleansing, it should be lint free, for lint can hold or enmesh food particles seeded with bacteria.

(9) As plastic reeds are not injured by twenty-four hour soaking, we recommend keeping them in hypochlorous acid solution 5-10 parts per million; the same dilution as used in swimming pools (zonite or clorox). The mouthpieces may be similarly treated.

(10) Contact is necessary for transfer of microbial infection, as the strictly airborne organisms are virtually harmless.

(11) Among the antiseptics tested for cleansing and antibacterial purposes were:

- (a) A saturated solution of boric acid (has lowest germicidal coefficient).
- (b) Hydrogen peroxide, full strength (a safe but deteriorating oxidizing antiseptic).
- (c) S T 37 Sharps and Dohme 1:100 and 1:200 (a safe pleasant-tasting antiseptic).
- (d) Dobells solution (contains Phenol), one part to 3 to 5 parts, used often as a mouthwash.
- (e) Hypochlorous acid (clorox Daikins solution, Zonite, etc.) in dilutions of 1:10,000, 1:100,000, or 5 parts per million.

This latter is the strength used in swimming pools and is probably the most widely used antiseptic today. However, it bleaches and softens reeds.

- (f) Bactine, one to five teaspoonfuls to a pint of water. Recommended for its high antibacterial action.
- (g) Rubbing Methyl, Propyl, or Ethyl alcohol will kill all bacteria and spores if exposed for from one to ten minutes. Methyl and Propyl alcohol are poisonous if imbibed in large amounts. Ethyl is the safe alcohol for brass instruments.
- (h) Zephiran chloride (has high germicidal coefficients against most pathogens) in dilutions of 1:20,000 with exposures of ten minutes. The temperature varies the bactericidal efficiency, for at body (mouth) temperatures the dilutions may run as high as from 1:40,000 to 1:70,000 for some streptococci. This antiseptic like the others is non-irritating to delicate membranes. In dilutions of 1:1,000 it will not injure the oral membranes which are in contact with the instrument mouthpieces.

All of the above antiseptics, in correct dilution, are therefore safe on membranes, except the alcohols and mercurials.

- (i) Azochloramide, one tablet to two ounces of water (a safe oxydizing antiseptic).
- (j) Stainless methiolate 1:1,000 solution, the only mercurial antiseptic tested, has very strong germicidal coefficient, but is not too desirable on the mucous membranes of the lip.
- (k) Listerine is a safe popular antiseptic and mouthwash with mild antiseptic action.
- (l) Zonite is another non-poisonous, chlorine liberating antiseptic. It is useful as a mouthwash 1:100 solution (teaspoonful to a glass of water). It is one of least irritating antiseptics and can be used on reeds and mouthpieces.

All of the above antiseptics are colorless, and harmless in the dilutions indicated. They all have reasonably high germicidal coefficients if used in the strengths indicated, and if exposed long enough.

(13) Oral hygiene should be a strict must for all wind instrument players. The mouth may harbor literally millions of mouth bacteria, mostly micrococci, and probably multi-strain viruses. Therefore, mouthwashes, throat gargles, tooth pastes, and antiseptic candies are indicated. They should be used before playing wind instruments, if maximum safety factors from oral infection are sought.

(14) When the reeds, mouthpieces, joints of music instruments were washed in the above antiseptics in the strengths indicated for half to one hour, most bacterial counts dropped so markedly as to be almost negligible. Counts that ran into the millions of micrococci per 5 cc.'s of wash water dropped to a few harmless spreaders after soaking in any of these antiseptics. Soapy water, either ivory or green-soap, cleansing generally lowered the incidence of the delicate thermolabile oral microbes. The old adage, "Cleanliness Comes Next to Godliness," seems to pay off with mouth hygiene and sterile music instrument mouthpieces.

#### SUMMARY

Seventy-five public school band members had their mouthpieces tested before any oral or instrument hygienic measures were advocated. Reeds and mouthpieces—frequently foul smelling and loaded with mouth detritus and unexpectant exudated—when tested for bacterial content, showed astounding results. Literally countless millions of microorganisms, mostly mouth bacteria such as micrococci and putrefactive organisms, many of them hemolytic streptococci and staphylococci, were isolated and identified on blood agar plates. Such mouthpieces were obviously not only obnoxious, but *dangerous* too. Reinfection by the player is a definite risk, and if the instruments are exchanged, then respiratory disease transmission via the instrument definitely is possible.

Since hygienic oral measures have been enforced in this band, instrument mouthpiece tests have proved their effectiveness. From millions of possible pathogens, tests now reveal only a few harmless saprophytes and some micrococci.

Our observations indicated very little, if any, damage to reeds soaked in standard, non-irritating antiseptics, especially if they are set aside to dry out and harden for a few days.

The exceptions, according to musicians are the chlorine liberating antiseptics, such as Daikens solution, Chlorox, hypochlorous acid, etc. These are bleaching agents, which whiten, then soften, and finally harden the reeds, so that they are hard to play. However weak solutions, 10:1,000,000, do not affect them.

The writer has done much work with air, mouth, dust, book, and lip bacteria. *I have never seen such appalling bacterial contamination as can be washed from the mouthpieces of foul reed instruments.* Some plates were so rotten and evil smelling that they had to be thrown out. The blood was hemolysed by streptococci and decomposed by anaerobic spore bearers (food particle putrefying bacteria.) Cess pools could be clean by comparison.

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#### MORE HOMES HAVE TV THAN BATHTUBS

More American homes have television sets than telephones or bathtubs. While this does not indicate that more Americans watch TV than take baths, it does point out the tremendous success of the 12-year-old television industry.

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#### NATION'S LARGEST SOLAR FURNACE BEGINS OPERATION

A solar furnace capable of concentrating sunshine to temperatures approaching those of the sun's surface began operation recently.

Described as the nation's largest solar furnace, it will be used for laboratory testing of materials to protect soldiers against the thermal effects of nuclear and other weapons. It will also furnish valuable information on the effects of high intensity thermal radiation of materials.

The solar furnace actually consists of four major, separate components: the heliostat, test chamber, attenuator and concentrating mirror.

The sun's rays are "caught" by the 355 optically adjusted mirrors that make up the heliostat's surface. The parallel beams are reflected onto the concentrator placed 96 feet away.

Each of the 180 concave mirrors of the concentrator is adjusted so that a convergent and tremendously intensified beam of sunlight is focused into the test area within the test chamber.

The attenuator, a venetian-blind-like apparatus located between the concentrating mirror and the test chamber, can control the amount of solar radiation hitting the concentrator.

Although the "high temperatures" produced by the solar furnace is the expression used, Army scientists point out that in this device a pulse of extremely intense heat is produced and used for very short exposures. Materials under test are subjected to short, shutter-controlled exposures of high thermal flux at the four-inch focal point of the built-up solar radiation.

## How about Inductive Chemistry?

Sister Ernestine Marie

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Can we, should we change our methods more or less drastically in the field of secondary school chemistry teaching? During the years, our textbooks have grown, as piles upon piles of new matter have been added. But the presentation? Has that changed? Alas, no. We have accepted the staggering total of facts planted between the covers of our high school books—and we have tried valiantly (and vainly!) to teach that huge volume, just as we were taught chemistry one or two generations ago. We give our students the chore of memorizing preparations, properties, and uses of an endless line of elements and compounds; we insist that they “know” the old theories we learned and the new theories of today. Why? Because our textbooks still publish Dalton's Atomic Theory and Arrhenius' dissociation theory. After all, these were only theories and by definition theories hold only until better ones are found. In a history-of-science course these outmoded concepts have their place, but in a modern course in high school chemistry, must we spend precious time on them?

Again, in the field of industrial processes, our books proudly set forth the lead chamber and the Contact, the Nelson and the Downs, the Frasch and the Solvay, the Bessemer and the Open Hearth—all interesting for extra-curricular reading, but hardly imperative in the training of the future chemist or engineer!

If we but cut back, prune our massive tree of chemical knowledge to the stalks from which growth can spring, then and only then will we have a vital plant. If we teach fundamental chemical principles only and leave the verdant growth of descriptive chemistry for related reading activities, then our students will have some basic knowledge from which future chemical learning can develop.

In the secondary school, a dozen years of trials and errors have shown the following nine topics to be a good course nucleus:<sup>1</sup>

1. Atomic structure
2. Periodic classification
3. Equation balancing and the laws involved
4. Stoichiometric problems
5. Solutions, suspensions, emulsions and colloids
6. Acids, bases, salts and ionization
7. Gas laws
8. Redox reactions
9. Nucleonics and radioactivity

<sup>1</sup> Some teachers find a short deductive-type introduction and follow-up to Unit I necessary to set the course going; in other cases the elementary foundation is strong enough to permit a direct inductive approach.

If these theoretical topics are handled with an inductive approach in the classroom, then chemistry can be tremendously alive and students can find in it a challenge which they will do their best to meet. If, on the contrary, the matter is handled in the traditional dogmatic deductive manner, our students will have all love for science crushed out of them in a one semester siege.

As America's future security lies, in large measure, in the hands of us, the secondary school teachers of today, we owe it to ourselves, our students and our fatherland, to bring out the best in the scientific potentiality of the youth passing through our classes. Are we giving them all we should? All we could? All?

Let's investigate the "inductive approach" for a few minutes. What is it? It is merely a logical approach—a presentation of situations with which the student is familiar, and a gradual working from them to the unfamiliar so that the thread of continuity is not broken. It is a working from the known to the unknown, from the facts to the principle, uniting all these facts into a vaster entity, a generalization, known formally as an hypothesis, theory or law. For instance, let us take the idea of conservation. Much discussion on this topic has to be elicited from the pupils at first, since the majority have never delved beneath the surface in their everyday thinking. They have to be made to feel a vital interest in the work and to come to the realization that it holds the key to problems they have all met but could not solve. Give them the example of burning wood and start them probing. Would the products weigh the same as, more than or less than the wood? What reacted with the wood? Has it weight? Have all the products weight? Even the slowest student can be brought into such a discussion and can contribute to it. Only when the concept of combination and weight equality has been firmly established are the laws of conservation enunciated. They are then laws with meaning, not empirical statements to be memorized because the book has them in italics. The student has proceeded from a known fact to one that was unknown to him—he has solved a problem inductively.

In the realm of the laboratory, the inductive approach is most fascinating. No formal directions are given to the student. The topic of experimentation is assigned a week in advance and from there the student is on his own—free to look up information in any book available, guided only by his knowledge that, for a given element or compound, he has to determine the principal physical and chemical properties, and know the common test for identification. In addition, he must find, from the literature, principal sources of the substance, methods of extraction, commercial preparation, uses and structure. In this way, laboratory work becomes something new and interesting, not a mechanical repetition of something already known, not a cook-book approach to chemistry.

The more involved experiments are controlled by "guide sheets" distributed to the pupils as the assignment is made. For the experiment on reactions that go to completion the guide sheet is as follows:

1. Collect the necessary materials:

You are asked to perform two reactions that go to completion by the formation of a gas; two because a precipitate is formed; and two because a slightly ionized substance results.

2. Perform the experiment:

Report your work with ionic equations for each of these reactions and clearly indicate which ions are removed from the field of action.

With laboratory work guided in this fashion, students of varying mental calibres and varying interest can experiment in a much freer way, feel less "hemmed in" by constricting directions, and can organize and develop their own scientific knowledge. Is this not a better way, a saner way to train our youth? All are not equal in past experiences, present equipment or future capabilities—why should all be strait-jacketed to the same pattern of learning?

Is part of the trouble the teacher's fear of being herself unprepared, unqualified to cope with students of high mental powers? The only answer to that is obvious—the teacher must take all possible measures to make her own preparation and knowledge adequate. If our teachers are second-raters our students are started off under a handicap. Statistical evidence accumulated in four schools over a ten year period and in fifty schools in a year's study corroborates the fact that the inductive method is vastly superior in results. Is it a challenge we can take?

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#### "TATTLE-TALE GRAY" MAY BE ELIMINATED BY BASIC RESEARCH

"Tattle-tale gray," already greatly reduced as an obstacle to sparkling white clothes, may be eliminated completely by chemists who have been studying the hows and whys of a synthetic gum used recently as a laundering aid.

Chemists assembled for the American Chemical Society meeting generally agree that a synthetic gum, carboxymethyl cellulose (CMC), when added to detergents greatly reduces tattle-tale gray.

Tattle-tale gray is caused by laundry water dirt that is redeposited on clothes.

Although the gum additive helps housewives and laundries, chemists have not known why or how it operates.

A popular theory has been that CMC coats clothing fibers during laundering and prevents soil particles from clinging to them. Attempts to test the theory have been inconclusive because the amounts of gum adsorbed, if adsorbed at all, are too small for careful measurement.

However, a chemist "tagged" some CMC with radioactive carbon atoms incorporated into its make-up. Routine laboratory counters enabled him and co-researcher Clyde G. Inks to make the otherwise almost impossible measurements.

They found that, although the gum was not ordinarily adsorbed on cotton fibers, it coated the fibers if detergents were present. In the case of wool and some synthetics, the gum adsorbed was less than in the case of cotton.

Careful measurements showed a definite correlation between adsorption of CMC additive and reduction of tattle-tale gray.

## The "Crossover" Problem

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One of the recurrent technical questions on civil service examinations and correspondence school finals is the so-called "crossover" problem. This is commonly regarded as a "sticker" by examinees of almost all educational levels, and a very small percentage of students seem able to solve it. Analysis of the failures discloses an interesting hiatus in some of our instructional methods.

The "crossover" problem, basically is this:

Two pulleys,  $A$  and  $B$ , having radii respectively  $A$  and  $B$ , are separated by a distance  $S$ . Connecting these two pulleys is a belt,

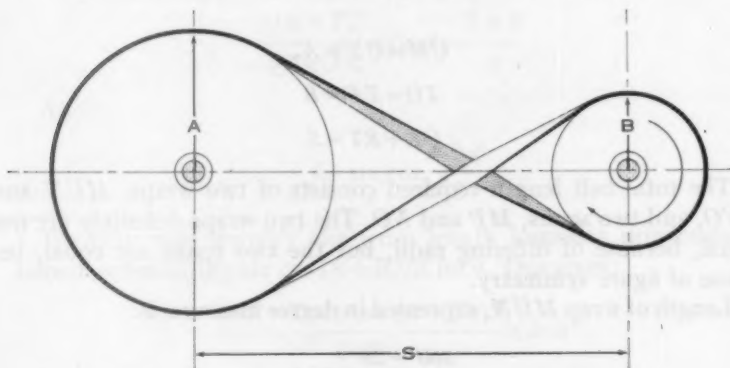


FIG. 1. The crossover problem. Shaft ends are sectioned, belt edge is solid black, inner surface of belt is stippled.

which forms a figure 8, as in Fig. 1. Pulley  $B$  rotates clockwise. From these data determine:

- Direction of rotation of pulley  $A$
- Relative speed of pulley  $A$
- Length of belt required.

Most examinees will immediately solve  $A$ , pointing out correctly that the bottom of pulley  $A$  will move in the same direction as the top of pulley  $B$ , and hence that  $A$  will rotate counterclockwise.

Similarly, most will apply the "driver over driven" formula to solve part  $B$ , correctly determining that the relative speed of pulley  $A$  will be  $B/A$ .

Part  $C$ , however, is not solvable by inspection. Most students at this point draw a new figure, sprinkling it with more or less appropriate symbols, and arrive at something like Fig. 2. From this figure, by inspection, the following relations are apparent:

The figure is symmetrical about the axis  $X-X'$ .

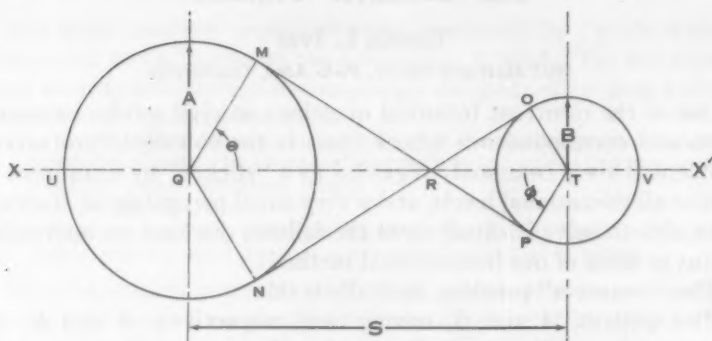


FIG. 2. Geometric restatement of crossover problem.

$$QM = QN = A$$

$$TO = TP = B$$

$$QR + RT = S.$$

The total belt length required consists of two wraps, *MUN* and *PVO*, and two spans, *MP* and *NO*. The two wraps definitely are not equal, because of differing radii, but the two spans are equal, because of figure symmetry.

Length of wrap *MUN*, expressed in degree measure, is:

$$\frac{360^\circ - 2\theta}{360^\circ} \times 2\pi A$$

and of wrap *PVO*, expressed in the same terms, is:

$$\frac{360^\circ - 2\phi}{360^\circ} \times 2\pi B.$$

Now, span *MP* is tangent to pulley *A* at point *M*, and to pulley *B* at point *P*. In consequence, it is perpendicular to radius *QM* of pulley *A*, and *TP* of pulley *B*. Because lines perpendicular to the same line are parallel to each other, *QM* and *TP* are parallel (WS 95).<sup>1</sup>

In Fig. 2, line *QT* is a transversal, cutting the two parallel lines *QM* and *TP*. Angles  $\theta$  and  $\phi$  are alternate interior angles in this system, and hence are equal (WS 100). Additionally, angles *TRP* and *QRM*, being vertical angles, are equal (WS 60). In consequence, triangles *TRP* and *QRM* are similar (three angles, WS 285).

From elementary trigonometry:

<sup>1</sup> References designated WS refer to numbered paragraphs in Wentworth, George, and Smith, D. E., *Plane Geometry*, New York, numerous printings 1910-1938.

$$\frac{QM}{QR} = \cos \theta.$$

And, as triangles  $TRP$  and  $QRM$  are similar:

$$\frac{QM}{QR} = \frac{TP}{TR} = \cos \theta \quad (\theta = \phi).$$

And, by proportion:

$$\frac{QM}{QR} = \frac{TP}{TR} = \frac{QM+TP}{QR+TR} \quad (\text{WS 269}).$$

So, substituting relations initially noted in Fig. 2:

$$\frac{QM+TP}{QR+TR} = \cos \theta = \frac{A+B}{S}.$$

And:

$$\theta = \arccos \frac{A+B}{S}.$$

We may now simplify the wrap length formulae previously obtained, substituting  $\arccos (A+B)/S$  for  $\theta$ . This gives:

$$\frac{360^\circ - 2 \arccos (A+B)/S}{360^\circ} \times 2\pi A$$

and, remembering that  $\theta$  has been shown equal to  $\phi$ :

$$\frac{360^\circ - 2 \arccos (A+B)/S}{360^\circ} \times 2\pi B.$$

Total wrap length is the sum of these. Dividing numerator and denominator by two, and combining terms, we obtain, for total wrap length:

$$\frac{180^\circ - \arccos (A+B)/S}{180^\circ} \times 2\pi(A+B).$$

Length of span  $MP$  is the sum of the lengths of its two sectors,  $MR$  and  $MP$ . By simple trigonometry, these lengths are:

$$MR = A \tan \theta$$

and:

$$MP = B \tan \theta.$$

The length of a single span is their sum, which is:

$$(A+B) \tan \theta$$

and total span length, there being two equal spans, is:

$$2(A+B) \tan \theta.$$

This can also be stated, with unnecessary pedanticism, as:

$$2(A+B) \tan \arccos \frac{A+B}{S}$$

but, as  $\theta$  must be evaluated in any event, either by reference to trig tables or a slide rule (preferred method) or by solution of the series:

$$\frac{A+B}{S} = 1 - \frac{\theta^2}{2!} + \frac{\theta^4}{4!} - \frac{\theta^6}{6!} + \frac{\theta^8}{8!} \dots$$

(a requirement that has no place in an ordinary engineering examination), the simpler notation is preferable.

In its simplest form, total belt length, the sum of two wraps and two spans, is given by:

$$\frac{180^\circ - \theta}{180^\circ} \times 2\pi(A+B) + 2(A+B) \tan \theta$$

where:

$$\theta = \arccos \frac{A+B}{S}$$

By use of additional geometric construction, as shown in Fig. 3, span length can be determined by a second method. To perform this construction, extend  $QM$  (Fig. 2) through  $M$ . From  $M$ , along the extension of  $QM$ , lay off distance  $M-M'$  equal to  $TP$ . This is also equal to  $B$ . Figure  $MPTM'$ , having two equal sides parallel, is a parallelogram (WS 130), and the other two sides,  $MP$  and  $M'T$ , are also equal and parallel (WS 130).

As  $QM'$  equals  $A+B$ , by construction, and as  $MP$ , a desired span length, equals  $M'B$ , length of a span can be computed from:

$$(A+B) \tan \theta$$

avoiding the employment of the proportional relationship previously used. Note the identity of the answers.

Using the same construction and reasoning, and momentarily invoking the shade of Pythagoras, length of a single span is also given by:

$$\sqrt{S^2 - (A+B)^2} \quad (\text{WS 337}).$$

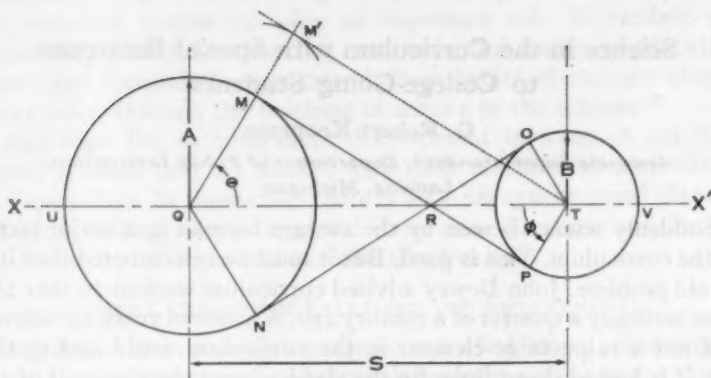


FIG. 3. Additional construction for alternative determinations of span length.

Observation of examinee performance on this question disclosed that if a successful answer was obtained, it was almost invariably obtained in less than 30 minutes; and that the principal cause of failure to answer the problem correctly was a combination of lack of ingenuity and ignorance of proportional relations. The salient relationship not known to most examinees is:

If

$$\frac{a}{b} = \frac{c}{d}$$

then it is also equal to

$$\frac{a+c}{b+d}.$$

This is clearly stated in many geometry texts, such as Wentworth and Smith (paragraph 269) in the form "In a series of equal ratios, the sum of the antecedents is to the sum of the consequents as any antecedent is to its consequent." Unfortunately, this apparently is not taught in some schools, and is not learned in many more. Also, for reasons not made at all clear, many students distrust the (perfectly clear and valid) standard proofs of this theorem. An algebraic proof can be demonstrated by setting up the three ratios as an equality, clearing of fractions, and making suitable substitutions from WS 261.

## Science in the Curriculum with Special Reference to College-Going Students\*

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Suddenly science is seen by the average layman as a major factor in the curriculum. This is good. But it must be remembered that it is an old problem. John Dewey advised curriculum workers to take this issue seriously a quarter of a century ago. A hundred years ago science was not a respectable element in the curriculum world and to this day it is looked down upon by the classical secondary schools of the Western World.

Curriculum workers, however, have recognized the role of science in general education and have created many excellent solutions in this field. New programs, new ideas and new recommendations have existed for twenty-five years. I predict that the next twenty-five years will see the rediscovery and implementation of these same ideas and programs.

In fact, it would be a great day for all of those interested in science if the ideas in the elementary curriculum bulletins of Ann Arbor of circa 1930 were suddenly universalized in the U.S.A. It would create a sensation if the philosophy and recommendations of the Yearbook of the National Society for the Study of Education of 1932<sup>1</sup> were suddenly to be implemented in American schools. But laggard behavior is characteristic of the curriculum.

If in the next few years those interested in helping our schools to deal better with the science problem will do four things we will make great progress.

First: Provide a friendly, congenial climate along with some advice.

Second: Free the secondary school of the stultifying control of the college.

Third: Provide some hard, round dollars with which to buy resources in the form of good teachers, laboratories and supplies.

Fourth: Become helping teachers in their own communities.

### THE IMPORTANCE OF SCIENCE IN THE CURRICULUM WORLD

Education is the vehicle of a growing culture. The teacher can't and shouldn't seek to redesign the social order. He won't need to. As Gerald Wendt has so aptly pointed out, science is busy making the present obsolete. The best the citizen and educator can do is to run

\* A paper presented at the Fourth Annual Mid-South Leadership Seminar at Memphis State University, Memphis, Tenn., June 24, 1958.

<sup>1</sup> Committee on the Teaching of Science. *A Program for Teaching Science*. Thirty-first Yearbook, Part I, of the National Society for the Study of Education. Bloomfield, Illinois: Public School Publishing Co. 1932.

alongside and give the steering wheel a tug from time to time. But our universal system can play an important role. Richardson optimistically points out that "... our universal system of education must, and fortunately can, extend these habits of thought almost universally, through the teaching of science in the schools."<sup>2</sup>

The hope lies in curriculum development in some of our best school systems that are staffed with good teachers, administrators and specialists. In these cases there is hope for synchronized plans of teaching, testing, counselling, and in-service education, and for the consummation of those plans in effective teaching.

#### SOME CURRICULUM FALLACIES AND ENTRAPMENTS

Right now the emphasis on science is leading schools into certain traps. Probably the fanatical layman is both the cause and the victim in these cases. At any rate, there'll be much waste motion and much corrective action to be taken.

Some of the more obvious fallacies and entrapments are the following:

1. Curriculum competition—there is only a given amount of time so science must crowd out some other curriculum newcomers—or may be it will crowd out some oldtimers like mathematics.
2. Dictation by the college and the practicing scientist—a tendency to handicap planning and experimentation by preconceived ideas.
3. Confusing the purposes of general education vis-a-vis vocational or professional education—straddling the fence so that new programs will serve neither set of purposes.
4. Threatening teachers—by unwarranted criticism, by testing programs or by forcing them to teach in a way for which they are quite unprepared.
5. Unreasonable expectations—asking schools to double their contributions without an increase in resources.

These are some of the obvious considerations that a responsible person must bear in mind as he enters this field of curriculum planning. These are mentioned because there is a tendency through increased criticism to create a sort of reign of terror which causes school officials to indulge in taking refuge in unreasoned action so that the cudgel hanging over their heads may be temporarily escaped.

This is a time for cooperative action involving all of those who wish to make real progress. Let us put press on all concerned but in an intelligent and decent manner. More good work and progress will emerge this way.

#### REDESIGNING OF INSTRUCTIONAL AND TEACHER EDUCATION PROGRAMS

Time does not permit a treatment of the entire problem but it

<sup>2</sup> Richardson, John S. *Science Teaching in Secondary Schools*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1957.

should be clear to any novice that it is necessary to make some basic changes in total instructional programs and in systems of teacher education. This redesigning must go beyond the teaching stage. Some community patterns are emerging. It is to be hoped that these community patterns may develop into substantial state patterns since teacher education can only be planned and handled at the state level. Regional accrediting processes and reciprocity programs of teacher certification which are now too specific and limiting in their influence could adjust to new state and community patterns as they develop.

Inadequate preparation of teachers is unquestionably the greatest problem in the field of science teaching. The high school graduate of today probably suffers more from this cause than any other. Elementary school teachers have until recently had almost no preparation in most cases. Secondary school teachers have been graduating in most cases with inadequate preparation in both content and method. With the advent of nuclear science one is now about as obsolete as the other.

#### PROGRAMS FOR PROSPECTIVE COLLEGE MAJORS

At the risk of putting new wine into an old bottle we now turn to the secondary school student who *may* become a college major in science or mathematics. What of him—his culture and his education? Some general proposals will be advanced concerning his education.

##### *A Good General Education*

First of all "Major," as we shall call him, should have a good program of general education. It is subsumed that science will be a basic element in this program—not so much in the sense of course work in science as in basic sense that critical thinking and an inquiring-creative-scientific-way-of-life will be developed through curricular experiences. This form of general education is needed if prospective Majors are not to be alienated from their destiny by the development of fears and dislikes for experiences in mathematics and sciences. More and more attention is turning to a scheme of general education starting in the home and continuing through life. This is essential to cultural developments in this country where we are suffering from scientific illiterates in the general population and illiterate scientists and engineers.

No need here to spell out the nature of this program of general education since its objectives and nature have been so ably restated in recent months by Richardson,<sup>3</sup> the Mallinsons of Western Michigan

<sup>3</sup> *Science Teaching in Secondary Schools*, *op. cit.*

University, Edward K. Weaver of Atlanta University and many others. Lazar of Ohio State and the Mallinsons state clearly that mathematics and science in the elementary school should be a form of laboratory science rather than taxonomic memorization.

The methods of organismic psychology have been adequately demonstrated. Teacher-pupil-parent planning has been adequately demonstrated and developed in the self-contained classrooms at all levels. It is a shame that the newer methods are almost universally scorned by science teachers. From a practical point of view many communities will find it best to concentrate on some systematic emphasis in the upper elementary grades and the junior high school grades. Without setting up separate courses it is possible for teachers at this level to use the tools of science and mathematics (together not separately) to solve individual and group problems. Reading, leadership, human relations and health activities all have scientific implications. This development in general education is essential if children are not to be alienated from science interests and a scientific approach to problems at an early age.

In general education at the early levels, as at later levels, the phenomenon of "matter-energy" will, it is hoped, be dealt with in terms of the latest scientific findings so that the concept of a body of content will not confront the young child. This seems to be the most promising development in science teaching.

The most basic element in the education of Major then should be a modernized general education well salted with science.

#### MORE SPECIALIZED EXPERIENCES OF THE SECONDARY STUDENT

*Individualization.* Rather than a regression into "more of the same" Major should have a curriculum of broad scope and one that is viable in terms of his purposes and paces. This is a terrific challenge to the secondary school but it is one that must be met. If the required course in physics and the sacred "16 units" are overthrown, what will remain?

It is to be hoped that since there is no fixed body of content for science that the emphasis will switch to setting up scientific experiences of considerable intensity. Since the scope of science is congruent with the scope of life itself, a comprehensive secondary school could start by utilizing experiences gained in its various courses not normally considered as science courses. For example, a good course in aviation is a wonderful vehicle. The same can be said of a course in health, if it is taught as a laboratory science by a capable teacher. Every course should be examined to ascertain its contributions to scientific thinking.

## THE PROGRAM IN SCIENCE FOR THE COLLEGE-GOING GROUP

In regard to the nature of planned science experiences for the college-going group there seem to be three options open if we are not to ignore the criticisms.

*First*, the existing offerings might be continued and made more universal for all college-going youth in all schools and every attempt made to improve the purposes, content and methods involved. This solution would undoubtedly be acceptable to many of the critics and especially to college people and standardizing agencies. The trouble is that it would fail to tackle the most serious problems in the field of science teaching. It would be a stop-gap solution which would leave responsible officials concerned with plant planning, curriculum planning and community relations without a firm foundation for future developments.

*Second*, required year-long courses in both the natural and the physical sciences might be carefully planned as requirements in a total structured program of general education. The pertinent mathematics skills would be integrated into this program. These requirements would be offered early enough to be embraced in the period of compulsory education. All youth would be educated together in this program and the objectives would be strictly those of general education which would mean emphases on citizenship and human relations as well as creative thinking, precise computation and critical thinking.

The other half of this solution would be the offering of elective courses for the college-going. These courses would cover the fields of science and mathematics and would be similar to those now offered in most large secondary schools. Every effort would be made to improve the purposes, contents and methods involved. With a good general education base it would be reasonable to expect that the interdisciplinary emphasis would be stressed.

*Third*, the latest research about learning and the new light that has been thrown on the role of science and the scientist would be brought fully to bear. This would mean that the obligations formerly assigned compartmentally to science and mathematics instruction would be assigned to the core curriculum through the sixteenth year or roughly through the tenth grade. A strong program of on-the-job in-service education supplemented by teacher education workshops would be used to help teachers see the role of science and to learn how to care for individual differences. Guidance and individualization of instruction would be stressed.

After the tenth grade a full program of individualized instruction along the line of an honors course would be provided on a twelve-month basis for college-going youth. As much as half or three-quar-

ters of a student's time might be devoted to the pursuance of projects of great depth and scope that would require reading, travel, writing, speaking, and carrying out scientific experiments.

This program for the last two years would require intensive programs of curriculum development involving all teachers and other forms of in-service education. The program would require a full range of small laboratories, an excursion program including access to other laboratories, and a good evaluation system.

The program would be expensive but probably no more expensive than the other solutions if the same criteria of good teaching were met through them.

This solution would be in accord with scientific education in its present state. The foundation would be sound even though the difficulties of execution might be great.

Not every school would be ready to try this solution just as some schools are not ready to try even the second alternative solution. Certainly experimental schools should consider only the fourth solution and none of the others.

But no set of courses can be tailored enough to meet Major's needs. The curriculum should be so flexible that Major might become an honor student tailoring his own curriculum to his own needs within limits. Two limitations only should be placed on his program. First, he should be constrained by any plan for guaranteeing a minimum of balance in learning that characterizes his school. Secondly, he should be constrained by the joint judgment of the teacher(s)-parent(s)-pupil planning team of which he is the subject member. While no one can accurately judge the limits of time involved it would seem that a self-directed student might spend up to three-fourths of his time on individual projects while a less well-integrated student might spend only a fourth of his time in this way.

The problem of time is bothersome when viewed in terms of the typical school day, week and year. Actually the problem of time is greatly exaggerated. Given the possibilities of a lengthened day, a twelve-month school year and an extended period of education permitted by our culture, time is no real problem. Rather attention should be focussed on aims, outcomes, methods, materials, facilities and evaluation.

#### NEW ORGANIZATION AND METHODS

It is obvious that the entire organization of a school would be changed if the principle of individualization were accepted. The same can be said for methods and materials.

One of the principal methods that must be explored is that of team-teaching. No one teacher (or counselor) can suffice. Some form

of a self-contained classroom, in which guidance is imbedded, accompanied by some form of cooperative or team-teaching seems like the best guess at this time. This system should produce scientifically literate citizens and literate scientists at one and the same time. This system is being explored but is being unjustly criticized by self-appointed experts and by those who do not appreciate that education, too, must adjust to a new way of living.

#### NEW LABORATORY FACILITIES AND METHODS

Many creative teachers of science have condemned the laboratory and the rat-maze methods that have developed in many laboratories. The essential point is that scientific processes should be learned through creative problem-solving experiences. Richardson<sup>4</sup> indicates the purposes and outcomes of the school science laboratory. The science laboratory can be used wisely or unwisely and Major should have access to a science laboratory in his school where real learning takes place.

Laboratory experiences and laboratory facilities are still planned in most schools on the platoon basis — a basis that denies the very nature of learning since it ignores pacing and individualization in general. In spite of cost and difficulties of scheduling the laboratory experience should take place in *ateliers* or small laboratories that the filled with all sorts of realia, growth experiments and apparatuses.

It seems as if the science room and the science laboratory arranged for platoons or masses must give way to all-purpose rooms supplemented by *ateliers* or small rooms plus storage spaces filled with well-cataloged materials.

The most significant development in the materials field is the utilization of the total environment as a laboratory for learning. This idea is old but mass education has not made much use of it. Present trends toward using industry, practicing scientists and parents are all to the good. Summer trips to Antarctica, winter excursions to the Amazon Valley, internships in Brookhaven and Oak Ridge are all within the realm of possibility today. The community school environment is the entire universe — a universe to be perceived by the power of reading, thought and imagination but also in many cases to be perceived firsthand so that intellect and emotion may in concert bring about the complete experience.

#### DEPTH AND CONTINUITY

The education of a dynamic secondary school student presents many problems. The easy solution is to let the mass influence dominate so that the school culture is typified by screaming bobby-soxers

<sup>4</sup> *Science Teaching in Secondary Schools*, pp. 70-73.

and big-muscled athletes chanting en masse the requiem of creativity and individualism. The complicated senior high school schedule worked out with moving blocks by a principal in September lends itself well to this development.

Depth and continuity of learning can only be worked out in terms of the individual. Much listening, waiting, counseling, experimenting, testing and venturing must go into the educative process. There must be a flexible decentralized organization before there can be individualized instruction. Thus the core class and the teaching team seem promising while the large class experiments built around the use of teaching aids seem unpromising.

Another aspect of depth and continuity deals with group sessions designed to lay a basis for understanding a principle, reducing a process to a semi-automatic and precise level, capitalizing on several experiments of several learners. This is the link between the older and the newer methods. Group sessions of this kind have been widely used in elementary education and in workshops for experienced teachers. There seems to be no good reason why they cannot be used in science more than at present. Certainly serious and purposeful learners all seek help from competent teachers in these respects.

#### SUGGESTED STEPS TO BE TAKEN AT THE LOCAL LEVEL

What course of action should a secondary school or school system follow when serious doubts arise about the science emphasis in the curriculum? The following are suggested:

1. Survey the existing situation in terms of such factors as student participation, organization, objectives, success of students in follow-up activities, success in terms of objectives and curriculum plan, methods employed, materials and other resources employed, etc.
2. Call in consultants from community, state and nation to help evaluate the data.
3. Revise the teaching plan through a community curriculum study.
4. Enrich consultation services for teachers from within the system as needed.
5. Make working arrangements with a few extra-community consultants from the state department of education and institutions of higher education.
6. Experiment and evaluate.
7. Throw much effort into a program of in-service education for *all* teachers.

#### SUMMARY

In the past we have not achieved too well in science instruction. We have been too satisfied with perfunctory teaching by teachers who often were inadequately prepared. We've often been concerned with curriculum offerings rather than results. We have tolerated unjust attacks on the schools as against a calm assessment of weaknesses and a common assumption of blame. Concerted cooperative action along with a greatly increased investment in education will pay dividends for the student and the culture.

## New Formulas for Logarithmic Interpolation

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Tables are employed for various purposes in the many theoretical and applied mathematical areas. With respect to logarithm tables, often a given antilogarithm or mantissa is not to be found as such in the table being used. The arithmetical value sought may clearly lie between two observed values. The mathematician is forced to resort to interpolation if his answer is to be reasonably accurate.

Interpolation is one aspect of table reading and interpretation which frequently spells difficulty for students of mathematics and science. Such is probably true in that most of the textbooks and supplemental materials which purport to treat the topic seem to be content to mention the technique, without adequate explanation which will enable the student to interpolate deductively later. It is not to be construed here that no attention is given logarithmic-table interpolation. The intention, however, is to emphasize that the needed applicatory information is not compactly presented.

To be sure, if the value wished is located half way between two observed values, the answer is quite readily obtained. Likewise, if the distance is an exact one-third, one-fourth, one-tenth, or some other clearly recognizable proportion, slightly more effort is required. The final outcome will be obtained with similar facility, since linearity is easily divisible.

Over a period of years, in this author's experience, students and applied mathematicians have demonstrated an interest in a systematic process which would enable them to enter a table and determine a given antilogarithm and/or mantissa. Few authors, it would appear, have met this need in a head-on manner. In some cases it has even been difficult to determine whether or not a given author has provided a workable procedure. Thus, those who have given thought and attention to interpolation—particularly in the area of logarithm—have not always met with the degree of success exacted by the applied mathematician.

Here, the author has constructed not one formula, but two of them: one for finding the antilogarithm, or number; the other for ascertaining the mantissa. The formulas involve essentially the same notations; but the order of their use differs. Then, too, inasmuch as  $N$ , the number sought, is the objective of Formula No. I, the given  $M$ , the mantissa given, is of basic importance. On the other hand, since "LOG," the logarithm sought, is the objective of Formula No.

II, the given  $N$ , the number given, is of basic importance.

The notations employed may be somewhat unorthodox in that they are intended to represent values which can be understood. The memory load—ordinarily required for arbitrarily selected symbols—has been noticeably reduced.

To maximize understanding, applications of the formulas have been simplified. The example employed for Formula No. I is the answer for the example given in Formula No. II. Likewise, the example employed for Formula No. II is the answer for the example given in Formula No. I. The author has made use of a four-place logarithm table in an effort to eliminate excess figures and computations. Hence, it is hoped that the objective of simplifying a would-be beclouded application has been attained.

FORMULA NO. I (Log given; find the number):

1. Formula.

$$N = SN \text{ (consider } C) + \left( \frac{Mg - SM}{LM - SM} \right) \left( \frac{LN - SN}{1} \right)$$

2. Notations.

- $N$  Number—the number sought
- $SN$  Smaller Number—the number shown in the table, represented by the mantissa immediately below the given mantissa
- $C$  Characteristic—the number to the left of the decimal point given in the logarithm
- $Mg$  Mantissa—the mantissa given
- $SM$  Smaller Mantissa—the mantissa shown in the table immediately below the given mantissa
- $LM$  Larger Mantissa—the mantissa shown in the table immediately above the given mantissa
- $LN$  Larger Number—the number shown in the table, represented by the mantissa immediately above the given mantissa

3. Example. Find the number for log 3.6565

4. Basic Values.

- $SN$  4,530
- $SM$  .6561
- $LN$  4,540
- $LM$  .6571

5. Substitutions.

$$\begin{aligned}
 N &= 4,530 + \left( \frac{.6565 - .6561}{.6571 - .6561} \right) \left( \frac{4,540 - 4,530}{1} \right) \\
 &= 4,530 + \left( \frac{.0004}{.0010} \right) \left( \frac{10}{1} \right)^* \\
 &= 4,530 + \left( \frac{.0040}{.0010} \right) \\
 &= 4,530 + 4 \\
 &= 4,534 \text{ (Answer)}
 \end{aligned}$$

FORMULA NO. II (Number given; find the log):

1. *Formula.*

$$\text{LOG} = C \text{ and } SM + \left( \frac{Ng - SN}{LN - SN} \right) \left( \frac{LM - SM}{1} \right)$$

2. *Notations.*

- LOG *Logarithm*—the log sought  
 C *Characteristic*—the characteristic of the log of the given number  
 SM *Smaller Mantissa*—the mantissa shown in the table for the number immediately below the number sought  
 Ng *Number*—the number given  
 SN *Smaller Number*—the number shown in the table immediately below the given number  
 LN *Larger Number*—the number shown in the table immediately above the given number  
 LM *Larger Mantissa*—the mantissa shown in the table for the number immediately above the number sought

3. *Example.* Find the log for the number 4,534

4. *Basic Values.*

SN	4,530
SM	.6561
LN	4,540
LM	.6571

5. *Substitutions.*

$$\text{LOG} = 3.6561 + \left( \frac{4,534 - 4,530}{4,540 - 4,530} \right) \left( \frac{.6571 - .6561}{1} \right)$$

\* Cancelling is optional.

$$\begin{aligned}
 &= 3.6561 + \left(\frac{4}{10}\right)\left(\frac{.0010}{1}\right)^* \\
 &= 3.6561 + \left(\frac{.0040}{10}\right) \\
 &= 3.6561 + .0004 \\
 &= 3.6565 \text{ (Answer)}
 \end{aligned}$$

Clearly, the foregoing formulas have been specifically designed for use in reading logarithm tables. The principles involved very well lend themselves to table interpolation generally. Although application has been made to logarithm, it is strongly suggested that this narrow aspect of mathematics be considered merely as a linear case in point.

\* Cancelling is optional.

#### BLOOD SUCCESSFULLY RECOVERED FROM FROZEN STORAGE STATE

A successful method of recovering whole blood from the frozen state that holds promise for an end to the chronic blood supply shortage has been reported.

The problems involved in using blood that has been frozen include the removal of glycerol, a preservative, from the blood, avoidance of contamination, and transfusion to recipients without harmful effects. This has been accomplished by a team of scientists who reported their technique in the *Journal of the American Medical Association*.

Frozen blood is stored in glycerol solution at minus 80 degrees and minus 120 degrees centigrade.

Researchers had been working on a sterile method of recovering blood from the glycerol solution with little success previously. Either the blood recovered was not usable, due to the amount of glycerol that could not be removed, or contamination interference.

The reporting scientists processed the blood in a fractionator, added glycerol and froze it. After storage at minus 80 degrees or minus 120 degrees centigrade, the blood was thawed and then deglycerolized in wash solutions. The blood was then stored for from three to 11 days in a standard refrigerator. The recovered blood appeared therapeutically comparable to the blood that is now used for transfusions.

#### ANTITUBERCULOSIS FACTORS IN MILK STUDIED

At least three factors in cow's milk inhibit the growth of the tuberculosis bacterium, a team of Czechoslovakian scientists reported.

After making several tests and analyses in order to concentrate the antituberculosis substance or substances, the scientists report that two "fat-loving" factors (lipophilic compounds that have a strong affinity for lipids or fats) and one "water-loving" (hydrophilic) factor inhibited growth of TB bacteria.

The anti-TB activities of the milk were effective in laboratory cultures of the bacterium, *Mycobacterium tuberculosis*. Previous research had shown milk inhibited the development of TB in mice.

Goat's milk and human milk also appear to have the inhibitory effect on TB bacteria's growth.

## Research and Engineering in an Industrial Laboratory

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If our present decade should require some descriptive phrase, I think the term "age of automation" would do it proper justice. Although in earlier decades there were some few industries and processes that were highly mechanized—including the automotive industry which incidentally, gave the world the term automation—now many things, many industries, and many services are with us today only because they were amenable to mechanization in the broad meaning of this word. Accompanying this marked change in the scheme of things has come a drastic reorientation of the role of research and engineering in our society.

According to a recent survey by the National Science Foundation<sup>1</sup> about 229,000 scientists and engineers were engaged in research and development (including engineering) in 1954, involving an annual expenditure of about \$5.4 billion. These figures represent about 1/4 of all scientists and engineers included in the survey. The others were engaged in non-R and D activities. Of this R and D total, 73% were employed in various industrial laboratories.

With less than \$200 million spent in 1934 this twenty-year growth has been truly phenomenal, approximating, with only minor dips, an exponential growth curve. This growth in R and D has been matched by an unprecedented flow of new materials, devices and processes that has enriched our economy.

Perhaps a more significant index of the growth of R and D is afforded by an examination of the R and D dollar in relation to the Gross National Product. These statistics are very revealing. In 1934 R and D expenditures constituted less than one quarter of one per cent of the GNP; in 1954 it was in excess of 1.5% and the most recent figures suggest an even greater rate of increase to an annual rate of about \$7.3 billion. This, of course, is not so surprising in the context of the ever expanding role of engineering and research in an economy dominated by technology. Projecting this trend forward twenty years without modification leads us to wonder whether far too high a proportion of the national wealth will be devoted to Research and Engineering. This is a problem for our economists to analyze and evaluate in terms of the classical yardsticks of profitability and rates of return.

<sup>1</sup> Reviews of Data on Research and Development, National Science Foundation, No. 9, February 1958.

However, I offer the opinion that the rate of growth of R and D funds will level off; but it must do so without impeding the progress of our technology and civilization and this can only be done effectively by upgrading the quality and caliber of the R and D effort. This means that the average productivity of the scientists and engineers—if productivity is the correct word to describe the output of scientists and engineers—must be significantly improved immediately and on a long-range basis. Our problem is to stimulate creativity and foster originality in order to increase the per capita output from those individuals we now have. This is one of the more important responsibilities of industry.

We hear conflicting reports about the apparent shortage of scientists and engineers. But that there is a shortage in the number and caliber of creative scientists and engineers, there can be no doubt. There is certainly no foreseeable lack of phenomena to discover, nor of devices to invent nor of funds to exploit things of economic importance. But unless we can train a generation of highly competent technical people and provide them a climate in which their creative instincts can thrive, we shall be unable as a society to foot the bill that the extrapolated R and D effort will require.

In spite of this expected leveling off of R and D activity the total effort is and will remain quite impressive.

What these statistics also reveal, therefore, as many of you are keenly aware, is that R and D is now big business and a vital corporate function. As such R and D has created its quota of knotty problems, among them how to increase the return on the R and D dollar. I will treat of some of these problems within the framework of my own experiences and with particular reference to the research end of the business.

In addition I propose to discuss management interrelation in research and development and to examine some of the lore that has grown in and about the concepts of research and development.

I am sure you will agree, on reflection, that within the past decade or so we have witnessed a profound change in the *scope* of our industrial laboratories. Until recent years research resided almost exclusively in our universities; development engineering was considered the special domain of industry. Also analytical studies were identified with the universities; intuition and notions were the trademarks of engineering in industry. These are somewhat harsh comments but they are in the main correct as this humorous, but true story related to me will illustrate:

"In 1918, I got a job as a draftsman with an airplane company that built seaplane trainers for the navy. Pioneer barnstormers were the chief designers. At one of their less productive design sessions, some-

one remarked that an eastern university was graduating aeronautical engineers and that it was about time to hire one of these experts.

"This was done with all proper decorum, including providing a private office for the Ph.D. in aeronautical engineering.

"We were launching on the design of a hydroplane and the graduate engineer was given the job of designing the empennage. After a couple of weeks, we were ready for the tail section and called in the doctor. He reported that he was getting along fine and had almost completed the vertical fin and rudder.

"Pandemonium broke loose and the chief called for a piece of chalk. He got down on the floor and sketched the outline of the fin and rudder. The others in the group suggested putting on a little bit here and taking off a little there. This process was repeated on the horizontal surfaces. When the group agreed, the chief turned to the good doctor and said: 'Get a piece of tracing paper—there's your tail section'."

The remarkable thing about designing airplanes by intuition is that so many of the pioneers survived their early efforts.

But times have changed and brought new dimensions in the outlook of both industrial laboratories and our universities. Industry has extended its prerogatives to include all facets of research and our universities no longer resist the temptation of including development work. I am not certain what impact this trend will have on our educational institutions. I am certain that industry will benefit enormously from this extension of its technological horizons.

It has always been assumed that the line of demarcation between research and development in an industrial laboratory can be sharply defined. As you are aware many definitions have been proposed drawing distinctions between basic, exploratory and fundamental research, applied research and advanced development—each definition purporting to circumscribe a precise, bounded and mutually exclusive area of intellectual activity.

In actual practice these lines of distinction are not clearly defined, but are fuzzy and dependent on the character of the enterprise and the perspective of the evaluator. However, much publicity has been given to these definitions, so much so that management, unhappily, is becoming concerned as to what is the fashionable and profitable course for a research and development organization to follow.

Perhaps the difficulty can be traced to a lack of appreciation of the operational character of research and development processes. It is interesting, but somewhat academic, to define research and development in terms of theoretical models and ideal scientists and engineers. It is certainly more meaningful and realistic to examine the processes of research and development as practiced by actual scientists and

engineers who are motivated by the values of our times.

Within the framework of an industrial laboratory research and development should be more properly considered as representing a continuous spectrum of activities rather than a discrete one. At one end of this continuum is pure or basic research in the classical connotation of the word—the quest of knowledge for knowledge's sake alone. At the other end of this spectrum is development culminating in a process or device ready for manufacture for a profit. Somewhere in the middle, subtly matching pure research at the one end and development at the other is applied research. One readily recognizes the two extremes. Where one draws the line or lines separating research and development is arbitrary and a matter of personal choice.

There is, of course, a danger in taking analogies too literally. In this case one must not assume that necessarily new things are created in an orderly fashion from basic research across the continuum to production. This occurs when new scientific discoveries are made that suggest industrial development. Obviously, much excellent research has its origin from the production and development end of the business. In the pursuit of these engineering projects the urgent need for new knowledge is uncovered. This is the feedback to the research scientist.

Historically it has been customary to divide the technological activities of an industrial laboratory into three unequal parts—basic research, applied research and development. As you are keenly aware one of the key management problems is how much emphasis to place on each part. Specifically should industry be at all concerned with the basic research end of the research and development spectrum? A parallel problem is whether all three parts should be autonomous at the middle management level or under single management. Compounding the problem is the difficulty of deciding what to include in development and what in research and whether applied research should be part of development or part of basic research or with both.

I should like to explore these several questions with you in the light of historical perspective.

The difference between basic research and applied research is one of objectives, motivations and attitudes rather than of techniques or methods. What may be classed as basic research in one laboratory would be applied research in another. The principal objective of basic research is to add knowledge to a field of science without reference to any specific application of the information derived, whereas in applied research definite technological considerations determine the field of work.

On the question as to whether industry should engage in basic research at all I offer these observations. During the past twenty years

while the economy was booming a strong case was made for basic research and it appeared that basic research had at long last won its spurs and no longer needed praise. I have no doubt whatsoever that everyone in industry concerned with this problem is now agreed that basic research is important. But what about urgency? Unless basic research is also considered urgent, it can never be considered fully accepted. It will be subject to the short term fluctuations of the economy, to be turned on when funds are available and off when funds are tight. This should not be considered willful action but rather a lack of understanding of the long-range nature of basic research and of a lack of appreciation of the urgency of research.

The case for basic research is not yet fully won. This is an important reason why an industrial laboratory must have a balanced program of basic research, applied research and development, both short range and long range, and only that amount of basic work that the laboratory can afford to protect against short term economic fluctuation.

Clearly, an industrial laboratory must broadly direct its efforts to scientific or technological problems which are related to the business of its company. With this in mind, the laboratory director must define within rather wide limits the general areas of fundamental work.

Merritt Kastens,<sup>2</sup> in his paper on "Research—A Corporate Function," has called attention to the fact that the kind of research supported by a company is strongly influenced by such factors as company orientation—is the company a raw materials processor as an oil company or a timber products company; or is the company market-oriented such as the pharmaceutical or food products companies; or is the company operation-oriented such as the communications group or automobile companies. Another factor is the competitive environment of the industry—does the growth of the company depend on introducing basically new products such as nylon, polyethylene or transistors; or is it a high production industry with very narrow profit margins, etc. An additional factor is the adequacy of the science base and the degree of sophistication of the technology of the industry—is it well established or is it heavily weighted toward art and empiricism.

Such factors dominate the research philosophy, specify the nature of the research staff, influence the attitudes of the research man toward his work and, most importantly, determine the organizational posture of research within the corporate structure. For these reasons industrial research laboratories differ from one another in important ways and therefore care must be exercised in making com-

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<sup>2</sup> Merritt L. Kastens, Research—A Corporate Function, *Industrial Laboratories*, October 1957.

parisons of the effectiveness of various industrial laboratories.

The profound changes in the scope of our industrial laboratories to which I alluded earlier are not without mixed blessings; they have created important problems of management. It is instructive to examine briefly the manner in which these changes have come about and the challenging problems that they have engendered.

If we were to examine the nature of the technical activities of our industries some fifty years ago, I believe we would find that based on today's norms there existed a rather low level of development with a few specialty industries such as chemicals and electrical more heavily involved in development engineering than others.

The source material for these development engineers was the available published literature consisting of a few journals, texts and handbooks plus the creative output of the few university research laboratories. In short the existing equity of basic knowledge, and more importantly, the rate at which this knowledge was increasing were not sufficient to match the insatiable appetite of the development engineer in these rapidly growing specialty industries. The success of the new products that were developed and the overwhelming competitive advantage that these companies acquired as a result of new and better products due directly to dynamic development groups created even greater pressures on the engineers for new devices and better processes. It is perhaps difficult for us in this rather sophisticated world of today to capture the excitement and anticipation that surged through men when such inventions and discoveries were announced as nitrogen fixation, wireless telegraphy, liquefaction of helium gas, stainless steels and others.

It was quickly ascertained that the real bottleneck was depletion or lack of basic scientific information in certain rather narrow fields of vital importance to the growth of these industries and in addition poor and inarticulate communications between basic research scientists and development engineers that prevented the full and rapid exploitation of existing knowledge.

This situation was remedied by a rather bold and imaginative decision by management.

Industry would acquire a basic research staff as an integral part of the industrial laboratory. These early announcements made it clear that it was the intent that research scientists should engage in basic research to create new knowledge in fields of broad interest to the company and; furthermore, these scientists must interact with development engineers for the purpose of communicating new ideas and stimulating development activities. This is not to say that the feedback from development engineers to scientists was not equally stimulating.

Basic research and development engineering were now part of a single laboratory with common management and the early successes of this arrangement are a matter of record. No one will deny that out of this marriage evolved the basis for our present expanded knowledge and our enormously expanding economic potential.

As these laboratories increased in size and stature, as the development activities grew technically more sophisticated and complicated, and as the manufacturing processes of new materials and new devices became more involved and more demanding of technical skills, the role of the research worker in our industrial laboratories changed.

World War II left its imprint on our laboratories, for all scientific manpower was brought to bear on military problems and nearly all technical people became identified with development and production. So thorough was the integration of research scientists and engineers during the war that research scientists completely lost their identity and long-range research in its pre-war sense was almost non-existent. This was the second significant change in the evolution of our industrial laboratories.

Under these circumstances interaction between scientists and development-production people was nearly perfect. And the remarkably successful military devices that resulted from this interaction—radar, atomic bomb, guided missiles—demonstrated to management in most forceful terms that interaction between scientists and engineers was directly responsible for a phenomenal increase in creative output. Basic knowledge was being applied to the design of devices and processes at an optimum rate, during the war and immediately thereafter.

Frederick R. Koppel,<sup>3</sup> president of A. T. and T. in commenting on basic research stated, "Basic researchers and development engineers, working fairly close to each other in a dynamic atmosphere, sharpen each other's wits. Why then should an industry choose to do without this stimulus—in fact, how can it afford to do without it?"

As a matter of historical fact this close coupling between basic researchers and development engineers is responsible in large part for the dramatic shortening of the time spread between a basic discovery and a commercial product. It took over 50 years (1820–1876) from Michael Faraday's basic discoveries to Alexander Bell's commercial adaptation; it took only 5 years (1948–1953) from Bardeen's discovery of transistor action to commercial exploitation in practical devices. Can there be a more powerful motivation for industry to insist on basic research in the industrial laboratory?

It is interesting to observe that although the time span between discovery and adaptation has been markedly shortened through interaction, there is no simple formula that I know that will increase the rate

<sup>3</sup> Frederick R. Koppel, *Basic Research Pays Off*, *Product Engineering*, February 24, 1958.

of basic discoveries other than to staff the laboratory with the best possible people and provide them with a stimulating environment.

This intermixing, however, carried with it the hectic atmosphere common to all industrial engineering establishments, wherein the day-to-day problems seem to prevail and basic research found itself unable to free itself from the day-to-day product improvement problems, quality control and the aggravating interruptions caused by "putting fires out."

A good thing was being run into the ground. As a carry-over of a war-time philosophy, long-range research programs were considered important but not urgent. This insidious philosophy if it were to prevail in peacetime would certainly wreck the long-range product potential of an industry.

The alarming drop in creative output resulted in a third major change in the character of our industrial research and development laboratories. The natural consequence of this obvious conflict of interests resulted in a trend toward complete disassociation of basic research from development engineering activity. This became the order of the day. Research laboratories were erected in the most remote locations possible.

This change in policy on the part of management corrected, to be sure, one flagrant abuse of research talent—namely, interference with long-range research programs by the numerous urgent short-range "emergency" development programs. Also the autonomy granted the research laboratory provided an effective management protective mechanism against unreasonable demands on research.

Although isolation solved the problem of interference, it created an equally if not more critical problem—severing of an important communication line between research and engineering. The process of interaction which proved so valuable a technique for stimulating technical people was now stifled for it became increasingly difficult to get together.

It was assumed that complete isolation of the scientist was mandatory in order to permit freedom of thought and action in basic research. There is good evidence that this is a false assumption. The presence of a research laboratory in close proximity to development and production people is not a depressant to creative effort as has been assumed, but can be and is stimulating if adequate safeguards are available to prevent the abuses we have discussed. These safeguards can be provided through autonomy of the research laboratories.

This trend toward isolation of our research has, however, uncovered and brought into sharp focus a problem of major proportions, and one that has been with us for some time but tolerated because

of the lack of an adequate solution. The problem is—how does one insure that the results of research are given sympathetic and positive consideration by the development and production groups? A natural corollary is—how far should a research organization go toward development before letting go of a promising piece of research? There is ample evidence to demonstrate that in more cases than not the industrial scientist becomes frustrated in his attempts to establish the ultimate validity of his research. Too many fine pieces of work end up in reports because of the lack of an effective mechanism of following through.

It is therefore apparent that there exists a missing link in the chain of events from conception to application, particularly in those conceptions that may have a major influence upon future trends. There is the school of thought that suggests that research should end in a report and that some other group should pick up the information and continue development. This point of view relies too heavily on the whims of the "other group" and does not provide the positive action necessary to insure results.

A more realistic approach would be to provide an organizational mechanism that would permit the conceptual idea to be carried to a more advanced state of development where possibly the economic justification is apparent and reasonably well assured. I hasten to add that this does not mean that the individual scientist performs the linking function. It does, however, clearly spell out the necessity for providing a facility and organization dedicated to these principles.

A brief case history from our Scientific Laboratory file may serve to illustrate the point: a research metallurgist, after several years of intensive laboratory work, devised an improved structural material. Laboratory scale experiments were not sufficiently conclusive to prove manufacturing adaptability and, therefore, bulk size heats of the material had to be undertaken. Immediately, numerous problems of material and process control appeared which were not discernible in the laboratory. A completely new set of circumstances were encountered, and one found that, while the initial objectives were well received by the operating division, continued failures in developing the bulk processes interfered with the normal procedures within the productive facility and severely tried the patience of the production engineer. Unless an organization has the equivalent of a pilot facility, the natural tendency would be to defer further activity and finally to discount the potential possibilities and allow a brilliant research effort to die on the vine.

This, however, can be typical of many situations in all areas of research effort and points to the necessity of carrying on developments far enough within the organizational control of research so that a

reasonably complete process can be handed to an operating division.

Such an organization and facility entail an enormous capital expenditure. Unfortunately, there are not many organizations large enough to carry on such a program within their own facilities. The fact remains, however, that such a mechanism is necessary to take full advantage of the investment in basic research.

There are widespread indications that industry is beginning to recognize the necessity and the wisdom of containing within a single integrated area all the elements necessary to follow through from conception of an idea through development and on to production. Such an integrated technical system, of course, must preserve the autonomy necessary for self expression. I believe our modern industrial research organizations are due for their fourth major corrective change.

At Ford Motor Company we have been able in large measure to apply the principles developed in the foregoing analysis to our own research and development activities. As part of Ford Motor Company's top management policy of delegating responsibility and commensurate authority to the lowest practical echelon, the research laboratories have been given a high degree of autonomy and independence in formulating programs and budgets.

As a result of this management policy we have been able to provide our technical managers and our scientists and engineers greater freedom in the selection of programs and problems than would normally be the case in an industrial laboratory. And this is beginning to pay off—both in the increased sense of responsibility that our senior scientists and engineers show in the selection of problems and in the vigor and resourcefulness with which these problems and programs are pursued. It is especially gratifying, from an industrial laboratory point of view, to see basic research results pushed into the production payoff area without external pressures from the operating divisions of the Company.

And now to another problem of research management.

When we spoke earlier of an integrated technical system, we meant more than an agency for both the generation of new concepts and the implementation of them from the idea stage to industrial exploitation.

We consider as pertinent to the success of a research organization the ability to cross discipline boundaries in the concerted attack on a scientific or technical problem. The successful war-time onslaughts on the technical problems of radar, atomic energy and the other crash program successes alluded to earlier taught us another important lesson: that the classical boundaries between scientific disciplines have lost a good deal of their meaning.

Our universities and industrial laboratories have retained stead-

fastly an outmoded departmental structure that owes its origin to the professional prejudices of the 18th century rather than to any logical scientific reason. Yet, when confronted by the need to generate and solve subtle scientific and technical problems, it is often the limbo between departments where the solution lies. I strongly suspect that the reason so many important technical problems have not been solved is not because of subtlety or complexity, but because they are in a no man's land where the strict professionals shy away. Examples are many and legion. But I think that it is fair to say that the perfection of radar would probably have been delayed unduly if war psychology had not forced us to abandon our classical procedures for carrying out research—procedures which we quickly readopted once peace was established. Microwaves were in just such a limbo between physics and electrical engineering and therefore the province of neither.

It is customary for professional men, individually and collectively to stake out a broad technical area and claim its development as their own with trespassers not welcome. The basis for this action is an initial specialized knowledge of the field, and this is as it should be. Practically all of our engineering and scientific professions originated in this manner. Whether a given technical profession will grow and retain its identity will depend on the degree to which its members are capable of solving the fundamental problems that arise. Basic problems will not remain unsolved in this day of intense scientific activity and competition. We find the mathematician applying information theory to communications problems and taking over what was the prerogative of the electrical engineer; the astronomer applying celestial mechanics to missile, rocket and satellite problems and inching out the mechanical engineer; the physicist becomes a metallurgist in order to cope with the subtleties of purity so vital a part of nuclear and semiconductor technology; and the chemist becomes a solid-state physicist when it becomes pertinent to probe solid surfaces in their interaction with the external atmosphere; the geologist and chemical engineer apply their knowledge to mining problems and are pushing the mining engineer into the background. And so it goes. As we view the broad sweep of technological progress now underway, with basic contributions pouring in from all the sciences, one can feel the buckling of the classical engineering and science specialty boundaries and can sense that we are in for a high rate of obsolescence in engineering and in some of the sciences.

The problem in research management is to modify this time-honored regard for the discipline per se and to foster instead a healthy mechanism for commuting back and forth across these invisible demarcation lines. The creative scientist and engineer must be encour-

aged—in fact, pushed—to change his area of interest several times during his professional career. Crossbreeding and subsequent fertilization of new ideas is most effective when carried out within a single mind. The responsibility of the research organization in this realm is to provide not only the mechanism to do this but the climate where such activity thrives. Not many industrial laboratories—nor university administrations for that matter—have properly recognized this important change in our scientific pattern. Perhaps a noteworthy exception is to be found here at the University of Chicago where the research institutes founded after the war were designed quite specifically to meet this objective head-on.

In closing this paper on research in our industrial laboratories, it would be appropriate to quote from Vannevar Bush's<sup>4</sup> "Science—the Endless Frontier (1945)":

"In the 19th century Yankee ingenuity, building largely on the basic discoveries of European scientists, could advance the technical arts. Now the situation is different. A nation which depends upon others for its basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade."

These comments are as pertinent now as they were in 1945.

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<sup>4</sup> Vannevar Bush, *Science—The Endless Frontier*. (A Report to the President). Office of Scientific Research and Development, 1945.

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#### WEATHER-SENSITIVE WINDOW OPENS, CLOSES AUTOMATICALLY

A window that can be controlled by weather conditions has been perfected by the Truscon Division of the Republic Steel Corporation.

Called "wonder window," it reacts automatically, closing if the temperature inside the house drops below a pre-determined setting, rain or snow falls, or a strong wind blows.

Reaction of the window to rain and snow is determined by two "electric eyes" outside of the window just below the sill. When rain or snow contacts the eyes it completes a circuit and electronic relays actuate an electric motor causing the window to close.

A tiny mechanical flapper that is placed in a panel above the window reacts to winds over certain velocities.

The experimental window is made to serve as its own storm window. Each vent consists of two panes of glass sealed together after the air is removed from between the panes. It is weather stripped with a tight sealing vinyl.

Every time the wonder window opens, a screen automatically rises from under the sill. When the window closes, the screen backs down into its housing. The screen always operates automatically regardless of whether the vents are operated manually or automatically, so that you never have to look through a screen when the window is closed.

The company, however, does not plan to market the window either at present or in the foreseeable future.

## The Status of Secondary Science Education in the State of Ohio

(Abstract)

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As our country experienced industrial development and technological advancement, the need in the field of science for highly educated personnel has increased rapidly. A potential supply of such employees is the graduating classes of colleges and universities which in turn are dependent upon graduates of the secondary schools of America. It is, therefore, the responsibility of these schools to provide for their students an opportunity to acquire an adequate education in the various areas of science. Are the schools fulfilling this obligation? An objective answer to this question should be determined through an analysis of data resulting from intensive study of current science programs as found in the high schools.

This investigation of the status of secondary science education in the State of Ohio was primarily concerned with a study of course offerings, number of students enrolled in the various science classes, and total teaching load of each instructor offering one or more science courses.

The procedures used for securing data pertinent to the problem involved four steps. They were:

1. *Compilation of the sample.* The 161 high schools operating in 16 Northwestern Ohio counties constituted the main sample. An additional 50 high schools were chosen from the state at large by using the random selection process. Included in both samples were city, exempted village, and county high schools.

2. *Mailing inquiry forms to all members of the sample.* To insure as high a return as possible, two mailings were sent to each school not responding to the earlier request. The inquiry form obtained data on science course offerings, number of sections of each, total enrollments in each science course and section, enrollments in each grade—9 through 12, and the science course sequence followed. A request was made for a copy of the school's 1957-58 schedule of classes and teacher assignments.

3. *Tabulation of all data.*

4. *Comparing data obtained from the schools located in Northwestern Ohio and those obtained from the state at large.* This comparison was statistical in nature and was made by using the chi square formula.

## FINDINGS

The data collected from the various high schools were analyzed with respect to school size, science offerings, enrollment in the various science classes, the frequency and distribution of part-time and full-time science teachers, teaching combinations in science and with other academic or nonacademic subjects, the length of periods utilized for both class and laboratory work, and the total load carried by instructors teaching one or more science classes.

In this investigation, a full-time teacher is considered to be one who teaches only in the several fields of science. A part-time teacher is one who teaches one or more science classes and some non-science subject. Study hall duty was not considered to be a subject assignment; it was, however, used in calculating the total load carried by science teachers.

Inquiries were mailed to 161 high schools operating in 16 Northwestern Ohio counties and to 50 high schools in the state at large. Since 121 forms were satisfactorily completed by schools in the main sample and 38 in the random sample, the results of this investigation were based upon data supplied by approximately 75 per cent of these schools. These 159 high schools represent 16.5 per cent of the 966 senior, four-year, and six-year public secondary schools operating in Ohio during the 1957-58 academic year. The scope of this study did not take cognizance of the junior high school or of the 7th and 8th grades in the six-year high schools.

*School size.* Information pertaining to number and size of these high schools showed that the ones having enrollments of less than 500 were most common in Ohio. In fact, 80.5 per cent had enrollments of less than 500; 53 per cent were below 200; and roughly one-sixth were below 100. Nineteen and one-half per cent had enrollments of 500 and above.

*Science offerings.* Science offerings varied somewhat with school size. With the exception of seven high schools which offered only two science courses, each school had at least three different science subjects available. Fifteen per cent of these schools offered one or more advanced courses. A further breakdown of data showed that 92 per cent of the schools offered general science; 100 per cent offered biology; 59 per cent offered chemistry; and 45 per cent offered physics. The most frequently mentioned advanced courses were physiology, astronomy, and physical science. Most of the smaller schools alternated their physical science offerings; thus all four major courses were available to each student during any four-year cycle.

*Science enrollments.* An analysis of the data disclosed that approximately six out of 10 students attending high school in Ohio were en-

rolled in one or more science courses. These were distributed in such a way that 25 per cent were taking general science; 21 per cent were in biology; 10 per cent in chemistry; and five per cent in physics. Comparing the enrollees in each course with the number of students in each grade, it was found that 80 per cent of the freshmen took general science; 74 per cent of the sophomores were in biology; 37 per cent of the juniors in chemistry; and 23 per cent of the seniors in physics.

Some variance was noted in the class size of science offerings. As a whole, small schools had fewer students enrolled in each science class than their larger school counterparts. Enrollments in physics averaged smaller than in the other sciences. The average of class size and the extreme range of size were: general science, 30 and 14 to 41; biology, 28 and 6 to 41; chemistry, 21 and 4 to 35; and physics, 17.5 and 6 to 30.

*Number and kind of science teachers.* An interpretation of data pertinent to the number of science teachers revealed that the 159 high schools had a total of 446 teachers offering one or more science courses. Of this number, 297 were part-time teachers while 149 were full-time teachers. One-hundred-fifty of the part-time and seven of the full-time teachers were offering science courses in schools with enrollments of less than 200. Since there were 84 schools in this category, only one in 12 had a full-time science teacher, and the ratio of part-time to full-time science teachers was 21 to one. On the other hand, 35 part-time and 85 full-time science instructors were offering courses in high schools having enrollments of 1000 and above. Since there were 16 schools in this classification, there was an average of  $5\frac{1}{2}$  full-time teachers to each school, and the ratio of part-time to full-time science teachers was approximately one to  $2\frac{1}{2}$ . Each of the 159 high schools had an average of 2.8 science teachers.

*Teaching combinations.* There were 37 full-time instructors teaching only biology; 22 were teaching only general science; 14 chemistry alone; and there was only one full-time physics instructor. In the part-time category, 76 instructors were teaching biology; 52 were teaching only general science; 38 chemistry alone; and 20 were teaching only physics. In other words, 260 or approximately 58 per cent of the science teachers were teaching only one science subject. One-hundred-thirty-eight or 31 per cent of the teachers were teaching a combination of two science subjects. Of the remaining 48 science teachers, 37 or 8.3 per cent were teaching a combination of three science subjects, and the remaining 11 were teaching one or more of the advanced courses such as physiology, earth science, physical science, and astronomy. It was also observed that of the 138 teachers handling two science courses, 43 were teaching general science and biology; 29 chemistry and physics; 28 taught general science and

chemistry; 9 general science and physics; 8 biology and chemistry; and the remaining 21 were teaching combinations of odd science courses with general science or biology. Of the 37 handling three science subjects, 22 were teaching general science, biology, and chemistry; 12 taught general science, chemistry, and physics; two taught biology, chemistry, and physics; and one general science, biology, and physics.

It was further noted that 189 of the part-time science instructors were teaching in one other subject field; 82 taught in two other subjects; and 14 were teaching three. Mathematics and physical education—including coaching, were by far the most prevalent in the teaching load of these instructors; about 30 per cent had mathematics and 21 per cent had physical education. Social studies and English followed in this order.

A final facet on the subjects taught dealt with the total number of instructors teaching each of the four major science courses. The data on this topic disclosed that general science was taught by 196 teachers, biology by 199 teachers, chemistry by 151, and physics by 75. Since many of the instructors taught more than one subject, the total here exceeds the total number of 446.

*Teaching loads.* There was a decided lack of uniformity in the total teaching loads of science instructors in the various enrollment categories with respect to the length of the school day, the number of periods taught, duties other than those connected with classroom work, and provisions for laboratory experiences. Daily schedules varied between six and nine periods per day and the length of each period ranged from 38 to 55 minutes. There was a tendency for the large high schools to run a six-period day while most of those below the 500 enrollment level operated an eight-period day. Further analysis of data showed that a teacher in an eight-period day high school was involved in a greater number of assignments than his counterpart in the high school operating on a six-period schedule. The longest school day was from 8:30 A.M. to 3:45 P.M.; the shortest from 9:00 A.M. to 3:00 P.M.

Upon derivation of the mean for the total load, it was found that an average science instructor was one who taught 5.4 periods, handled a study hall for 0.70 periods, had 0.51 free periods, and was in charge of 0.26 extra duties such as hall supervision, cafeteria or lunch room supervision, care of the audio-visual equipment, and accountant for for student funds. The extremes showed that six instructors were teaching three periods and 112 were teaching eight periods per day, 136 had no study hall duty while one handled four each day, 218 did not have a free period while one had four each day, and 116 were handling extra duties of one kind or another.

Approximately 80 per cent of the high schools scheduled double laboratory periods for chemistry and physics courses, but only about one-fourth of the schools utilized double periods for biology. With but one exception, these double laboratory periods were found in schools operating on a schedule of seven or more periods per day. Two laboratory sessions per week was the usual custom when a double period had been scheduled.

*Validation.* It was initially hypothesized that no real difference existed between data obtained from the high schools of Northwestern Ohio and those from the random sample of high schools in the state at large. If this could be proved true, the idea that both sets of data arose by random sampling from the same population could be adopted. A statistical comparison of the two sets of data was made by means of the chi square formula. The results revealed that the minor variations in the recorded data were no more than would normally be expected by the law of chance. It was, therefore, assumed that the minor differences noted were insignificant and the two samples could be considered as members of the same universe.

#### CONCLUSIONS

The improvement of science education is of major concern to many segments of the population. Research findings in this field tends to indicate that a relationship exists between interest in science and the opportunity for studying science under an instructor who devotes a major portion of his time and interest to science teaching. Some implications resulting from this investigation point toward certain aspects of science teaching which need attention.

Since the classroom teacher is a major influence in the student's choice of a career, every effort should be made to staff the high schools with science instructors who are thoroughly competent in subject matter, interested in science teaching, and willing to work with students for the sake of stimulating and helping them develop the technique of critical thinking. To meet this criterion, boards of education and school administrators should do everything possible to consolidate their science offerings into the duties of one or more *career* science teachers.

The need for this is obvious since data from this study revealed that over one-half of the Ohio high schools had enrollments of less than 200 and that in this size category there was only one school in 12 which employed a full-time science teacher. The procedure of having one teacher handle the science classes is possible even in this enrollment group since most of the schools offered the three basic science courses. General science, biology, and either chemistry or physics

were available every year. Then on alternate years, the other physical science was offered. This one instructor would in many instances replace three part-time science teachers.

State Departments of Education have a responsibility in helping to correct the lack of uniformity in the teaching loads of science instructors. Through research and study, they should formulate an acceptable pattern of scheduling which could serve as a guide for all high schools in the state when setting up their own programs.

It was further recognized that the pattern of class assignments must vary according to the academic backgrounds of each individual instructor. This does not, however, justify giving one science teacher three classes of the same subject each day and another seven classes involving six different preparations plus one study hall. About one-half of the science instructors had a free period. Data on class assignments disclosed that most instructors taught five or six periods per day and supervised one study hall. In the light of present day emphasis on science, school administrators would find it advisable in working on schedules for science teachers to follow the pattern of assignments for vocational education personnel who are provided by law with two periods per day for the purpose of (1) individual conferences with students, (2) time for laboratory and demonstration preparation, and (3) opportunity for professional study and reading. This would constitute a major step toward increasing interest and enrollments in science and science teaching curricula.

Other duties involving such items as hall supervision, cafeteria or lunch room supervision, taking care of the audio-visual equipment, and working with various student activities outside the field of science were prevalent in many science teacher's assignments. If school people and the public at large really want a more efficient program of science education, it is necessary that science teachers be relieved of duties other than those which are directly associated with the actual presentation of each science subject and counseling and guidance services to prospective and current science enrollees.

In order to provide adequate educational facilities at reasonable costs, research studies on school organization and finance have indicated that each high school district should have a potential of at least 500 students. Secondary units operating with fewer students than this generally provide their young people with an inadequate, inefficient, and unduly expensive education.

Data from this investigation revealed that four-fifths of the high schools in Ohio enrolled fewer than 500 students and that the ratio of career science teachers to part-time science teachers was advantageous only in large schools. It would, therefore, seem desirable for each

small district to take immediate steps toward consolidation, thus giving its students an opportunity for acquiring an education of the highest quality.

The knowledge of subject combination taught by science teachers is valuable to colleges and universities in planning pre-service and in-service curricula. Science teachers should be given an opportunity to pursue an in-service graduate program leading to a master's degree. Course work in a variety of science subject matter areas should constitute the major portion of requirements for the degree. A decided improvement in the caliber of science teaching should result in communities surrounding centers offering such programs. Local school boards could give great impetus to the establishment of such programs by offering to their teachers an added salary increment for each six semester hours of graduate credit earned in science education courses.

When compared with figures recently released by the U. S. Department of Health, Education, and Welfare for the nation as a whole, the status of science education in the State of Ohio is better in respect to science offerings but about average in science enrollments.

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#### ATOMIC ENERGY HEATING FOR HOMES EXPECTED SOON

The world's first atomic house heating installations will begin operating in a few years.

Two such installations will be located in Sweden. Sweden is building two underground atomic reactors to be fueled by natural uranium mined within the country and to be moderated by heavy water.

One of the reactors known as R3 will heat homes in a new suburb south of Stockholm. The city of Vasteras, 70 miles west of Stockholm, will be the site of the second reactor which has been given the name "Adam." Heated water will be circulated to homes, replacing citywide oil heating systems.

The dual project will produce electricity as well as heat. They expect the reactors to generate a total electrical energy output of 200,000 kilowatts.

The two reactors will be buried in rock to minimize the danger of radio activity in event of accidents.

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#### PLAN TELESCOPE TO SCAN SKY FROM ORBITING SATELLITE

Astronomers wish to put a telescope on an earth satellite in order to observe the stars from outside the masking of the earth's atmosphere.

Dr. Fred L. Whipple, director of the Smithsonian Astrophysical Observatory and Harvard University astronomy professor, said the telescope would focus radiation from celestial objects so that an electronic scanning device can provide an image of an area of the sky at a monitoring station on the ground. The space telescope would be operated by remote control and there would be power in the satellite to keep it from rotating and spoiling the view and focus.

A wealth of new material would be obtained by the orbiting telescope in the far ultraviolet regions of the spectrum and this would increase our understanding of the universe.

## Data on Earth Satellites

Nathan L. Nichols

*Western Michigan University, Kalamazoo, Michigan*

The news of the launching of the first Russian Sputnik on October 4, 1957 electrified the world with the fact that artificial earth satellites were no longer a dream of the future. Since that time there have been six other successful launchings, bringing to seven the number of artificial bodies made to orbit about the earth. Of the seven, three have been slowed by the sparse air above the earth and have suffered the same burning fate as a meteorite coming into the earth's atmosphere. Together with the successes, there have been eight heart-breaking American failures and an unknown number of Russian failures.

Of the four satellites still aloft, one, the six-inch Vanguard, will probably circle the earth for two centuries, constantly giving out a radio signal operated by solar batteries. A second, the Russian Sputnik II, carried a small dog that remained alive for a week. Undoubtedly, information about its adjustment to the condition of weightlessness which is inherent in all satellites was radioed to the Russians. Objects inside a satellite "float" without exerting a force on the walls unless the satellite itself is spinning.

The most important scientific information gathered, so far, has been the discovery of a high-intensity cosmic radiation belt extending from about 400 miles altitude to several thousand miles. This belt seems to be donut-shaped extending around the earth's equator with the earth at the center of the "hole." This radiation at 1,200 miles seems to be about 10 roentgen/hour, but drops to about 2 r/hr at 17,000 miles. These values should be compared with the AEC recommended dosage of less than 0.2 r/week for humans. Information from the satellites also shows that the density of air at 150 miles is 10 times the predicted value. It is expected that future "little moons" will hand out information that may relate changes in the earth's magnetic field with the activity of sun-spots. The perturbation of their orbits should lead to information concerning the bulge at the equator. Also, by studying radio signals coming to the earth through the ionosphere, much should be learned that will aid radio communication.

The following is an outline of data concerning the seven successful satellites. Also included are data on the Pioneer, that failed to orbit, but which did get to an altitude of 79,000 miles in an attempt to hit the moon. During its short trip, it gathered much valuable cosmic radiation data.

## EARTH SATELLITES

*Name:* Russian Sputnik I. 1957 Alpha

*Lifetime:* October 4, 1957–January 4, 1958 (3 months).

*Orbit Angle to Equator:* 64.3°.

*Period When Launched:* 96.3 minutes: 1 hour 36 minutes.

*Apogee and Perigee:* 600 miles, 16,200 mph; 140 miles, 18,000 mph.

*Size and Weight:* 23 inch aluminum-alloy sphere; 184 pounds.

*Instrumentation:* 2 chemical batteries; 2 radios, 20.005 and 40.002 mc/sec, 1 watt, 9 foot antenna; internal temperature and pressure gauges:

*Comments:* Made 1,370 revolutions, 35 million miles; equatorial crossing changes 24.2 deg/rev westward.

*Name:* Russian Sputnik II (Muttik). 1957 Beta

*Lifetime:* November 3, 1957–April 13, 1958 (5½ months).

*Orbit Angle to Equator:* 65.4°.

*Period When Launched:* 103.3 minutes: 1 hour 43 minutes.

*Apogee and Perigee:* 1,000 miles, 15,100 mph; 132 miles, 18,000 mph.

*Size and Weight:* Stubby cylinder; 1,100 pounds.

*Instrumentation:* Chemical batteries; equipment for temperature, solar ultra-violet and X-radiation, cosmic rays, pressure; 2 radios, 10.002 mc and 20.005 mc (both dead after 1 week).

*Comments:* Had dog which stayed alive for several days in air-conditioned cylinder with instruments for pulse, respiration, blood pressure.

*Name:* American Army Explorer I. 1958 Alpha

*Lifetime:* January 31, 1958– (3–5 years expected).

*Launching Vehicle:* Jupiter-C, 70 feet by 6 feet at base: 4-stage rocket: 1st, liquid fuel to get to 300 miles altitude; 2nd, cluster of 11 9-inch by 3-foot solid fuel; 3rd, cluster of 3 of same solid fuel; 4th, 1 of same solid fuel but including satellite. Satellite spins about 700 rpm.

*Orbit Angle to Equator:* 33.5°.

*Period When Launched:* 114.8 minutes: 1 hour 55 minutes.

*Apogee and Perigee:* 1,573 miles, 13,700 mph; 224 miles, 18,400 mph.

*Size and Weight:* Cylinder, 6 inches diameter by 80 inches; 30.8 pounds.

*Instrumentation:* 2 mercury batteries; 2 radios, 108.00 mc at 10 milliwatts and 108.03 mc at 60 mw; equipment for: temperature, density of air, cosmic ray intensity, micrometeor impact. 4 whip-like antennae.

*Comments:* Ceramic cone for heat protection. Temperature range 32 to 104°F. Discovered belt of high-intensity radiation above 600 miles.

*Name:* American Navy Vanguard I. 1958 Beta

*Lifetime:* March 17, 1958– (May orbit for 200 years!)

*Launching Vehicle:* Vanguard, 72 feet by 4 feet at base; 3-stage rocket: 1st, liquid fuel to get to 40 miles; 2nd, liquid fuel to get to 300 miles; 3rd, solid fuel, breaks away from satellite at burnout.

*Orbit Angle to Equator:* 34.3°.

*Period When Launched:* 134.3 minutes; 2 hours 14 minutes.

*Apogee and Perigee:* 2,465 miles, 12,400 mph; 404 miles, 18,400 mph.

*Size and Weight:* Sphere, 6.4 inch diameter; 3.3 pounds.

*Instrumentation:* 2 radios, 108.00 mc at 10 mw, operated with mercury batteries (which went dead in 2 weeks), 108.03 mc at 5 mw, operated with 6 solar batteries; total instrumentation, 1.1 pounds.

*Comments:* Average temperature inside about 40°F. Solar batteries and transmitter should last lifetime of satellite. Temperature determined by shift in radio frequency. This rocket has been successful in only one of seven firings, (Dec. 6, 1957, Feb. 5, April 28, June 28, Sept. 26, 1958).

*Name:* American Army Explorer III. 1958 Gamma*Lifetime:* March 26, 1958–June 27, 1958 (3 months).*Launching Vehicle:* Jupiter-C with one liquid, three solid fuel stages (identical to Explorer I rocket).*Orbit Angle to Equator:* 33.4°.*Period When Launched:* 115.9 minutes. 1 hour 56 minutes.*Apogee and Perigee:* 1,741 miles, 13,450 mph; 118 miles, 18,860 mph.*Size and Weight:* Cylinder, 6 inches by 80 inches; 31.0 pounds.*Instrumentation:* Same as Explorer I, but has tape recorder to collect data for entire orbit: tape moves about 4 feet per revolution of satellite, plays back in 5 seconds. Insulated sections of nose skin serve as dipole antennae.*Comments:* Batteries lasted 2 months. Reaffirmed deadly belt of radiation above 600 miles. Temperature ranges in satellite OK for human survival. Density of atmosphere at 150 miles is 10 times expected value. Micrometeor impact not serious. (Explorer II, March 5, 1958, was in orbit OK but 4th stage didn't fire so speed too low.)*Name:* Russian Sputnik III. 1958 Delta*Lifetime:* May 15, 1958– (Expected lifetime several months.)*Orbit Angle to Equator:* 65°.*Period When Launched:* 106 minutes: 1 hour 56 minutes.*Apogee and Perigee:* 1,181 miles, 14,637 mph; 143 miles, 18,337 mph.*Size and Weight:* Cone-shaped, height 11 feet 9 inches and base 5 feet 7 inches; 2,925 pounds.*Instrumentation:* "2,134 pounds; chemical and solar batteries; magnetron, photomultipliers for sun's radiation, apparatus to register cosmic ray photons, magnetic ionized manometers, ionic traps, electrostatic flux meter, mass spectrometer tubes, apparatus to register heavy nuclear effect in cosmic rays, intensity of primary cosmic rays, micrometeors." (Russian press release.)*Comments:* Final rocket (probably 15 tons) also orbiting and visible to naked eye.*Name:* American Army Explorer IV. 1958 Epsilon*Lifetime:* July 26, 1958– (Expected lifetime probably about 1 year.)*Launching Vehicle:* Same as for Explorers I and III.*Orbit Angle to Equator:* 50.1°. Fired to Northeast. All others fired Southeast.*Period When Launched:* 110.2 minutes; 1 hour 50 minutes.*Apogee and Perigee:* 1,380 miles, 14,260 mph; 157 miles, 18,400 mph.*Size and Weight:* Same shape and size as other Explorers: 38.4 pounds (7.5 pounds heavier than others).*Instrumentation:* Used for cosmic ray studies only; 2 radios, 108.00 mc at 10 mw, and 108.03 at 30 mw (battery operated); 2 Geiger-Mueller counters; 2 scintillation counters on faces of photocells (can measure several levels of radiation).*Comments:* Radiation doubles for each 60 miles altitude above 250 miles up to apogee. (See Pioneer data below.) Dosage 10 roentgen/hour at 1,200 miles (maximum allowable human dosage 0.15 r/week). Radiation probably 6 Mev electrons or 40 Mev protons.*Name:* Pioneer. (This is a rocket, not a satellite)*Lifetime:* October 11, 1958 (disintegrated after 43 hours).*Launching Vehicle:* 88 feet long, 52 tons;

1st stage: Thor IRBM, 50 tons weight, 150,000 pounds thrust, liquid fuel;

2nd stage: modified Vanguard second stage plus 8 spin rockets, 2 tons, 7,500 pounds thrust;

3rd stage: Vanguard third stage, 400 pounds, 2,500 pounds thrust, solid fuel;

4th stage: 85 pounds, mostly instruments, 3,000 pounds thrust, solid fuel with retrorocket for braking.

*Firing Angle:* Fired vertically but wandered 3½° off path so missed moon.

*Maximum Height, Initial Velocity:* 79,000 miles, 23,500 mph (escape velocity about 25,000 mph).

*Instrumentation:* Batteries; ion chamber to measure radiation; electronic scanner; telemeters for meteorite density, earth and moon magnetic fields; TV infrared camera (to "see" moon's other side).

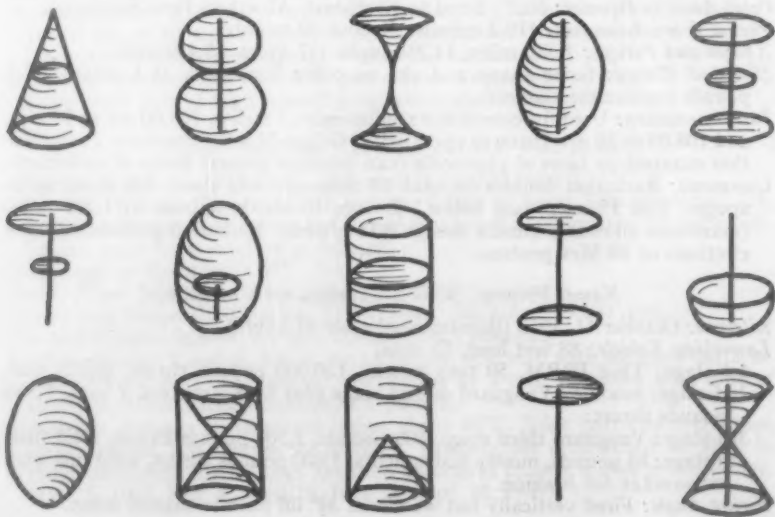
*Comments:* Weight at 80,000 miles is only  $1/400$  of value at surface so Pioneer "floated" at about same altitude for 2 hours. Radiation was found to decrease from 4 r/hr at 5,000 miles to 2 r/hr at 17,000 miles and even lower at higher altitudes, so danger to man may be less than feared. Tracking station operators talked between England and Hawaii by bouncing radio waves from the rocket. (First moonshot on August 17, 1958 was a failure.)

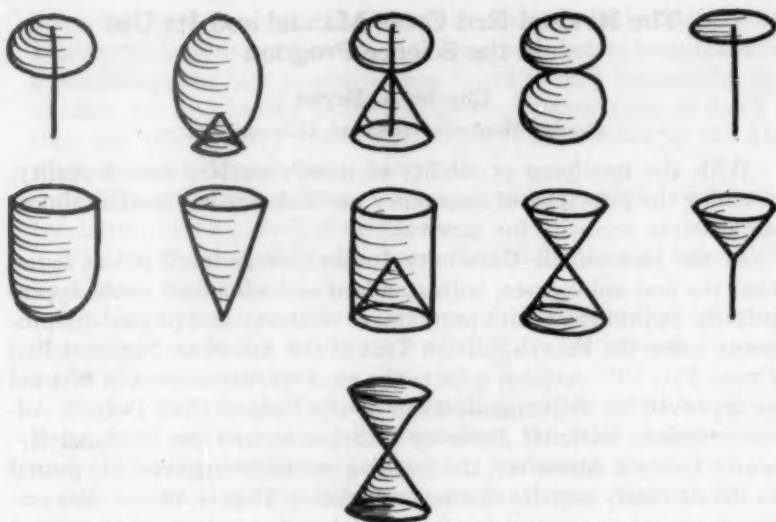
### A 3-D Alphabet

Lowell Van Tassel

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San Diego, California*

The inventor of the illustrated 3-D conic-sections alphabet was a student in my advanced geometry class this last year, James Nulton. About 30 minutes time was devoted one day in this class for the explicit purpose of attempting to instill a sense of geometric/physical perspective and space perception. I chose to do this by having each pupil devise a 3-D alphabet of some type, as solid block theater letters, etc. Much of the resulting calligraphy was interesting but trivial, being copies from memory (even some poor copies); and a few fair attempts at alphabets that were too complicated. Jim, however, produced this conic-sections alphabet that I thought was interesting, unique, and very original.





#### WORLD'S LOWEST TEMPERATURE RECORDED BY SOVIETS IN ANTARCTIC

The world's lowest temperature, 124.1 degrees below zero Fahrenheit, has been recorded by Russians at Sovietskaya, their Antarctic base.

This low temperature record from the world's "icebox" is within about six degrees of the coldest scientists calculate the earth might ever reach, or minus 130 degrees Fahrenheit.

The extreme altitude of Sovietskaya, some 12,000 feet, probably accounts for the very low temperature recorded there. Russian stations high inland in Antarctica have consistently been setting record lows during 1958, the first year of their operation.

#### LOS ANGELES CANINES STUDIED FOR AIR POLLUTION EFFECTS

Smog conditions in Los Angeles County do not worry the local dogs.

A study of some dogs raised in the smog area of Los Angeles County revealed that none of them suffered the expected respiratory tract illnesses.

Fifty-one canines were examined to compare their respiratory tract changes with dogs that had changes induced by exposure to a synthetic smog in inhalation chambers. The dogs studied had been exposed to natural air pollution as it occurs in the Los Angeles area for periods varying from four months to 18 years.

Unpublished studies have demonstrated that dogs exposed to smog in inhalation chambers experience a definite morphological change. The synthetic smog consisted of gasoline vapor plus ozone and ultraviolet light. The changes found in these dogs were not found in those dogs that had had exposure to naturally occurring smog during their lifetime.

## The Revised Red Cross Manual and Its Use in the Science Program

Charles A. Bryan

*Orange Memorial Hospital, Orlando, Fla.*

With the terrifying possibility of missile warfare now a reality, teaching the principles of emergency medical care has become almost an absolute necessity for survival.

At the Jacksonville University Junior College level, it was found that the first-aid courses, both standard and advanced, could appropriately fit into the health program, or anatomy and physiology program, using the Fourth Edition Text of the American National Red Cross. This 1957 revision reflects the most recent progress in first aid as approved by such organizations as the Federal Civil Defense Administration, National Academy of Sciences, and the National Research Council. Moreover, the teaching methods suggested are geared to the currently-popular discussion technics. That is, there is less emphasis placed on memorizing facts which will soon be forgotten if not used; and more concern with developing the attitudes, skills, and insights that would be necessary in the emergency situation. The two hundred thirty page text is easily assimilated by high school or freshman college students and contains two hundred fifty self-explanatory illustrations.

Recently the Red Cross has rendered their first aid and water safety programs more flexible, allowing more complete freedom for the instructor. The instructor may spend as little or as much time as desired and adjust the material to the students' capacities. Of even more importance is the fact that it is now possible for professional science teachers to be quite easily certified as Red Cross Instructors.

The course not only outlines care of the ill or injured until the physician arrives, but stresses prevention of the more common accidents. With ninety-six thousand Americans dying from accidents in 1956 this is an appropriate service rendered by the school to society. The major changes follow:

- (1) Only two pressure points are now taught, the brachial and femoral. All methods for control of hemorrhages elsewhere require direct pressure over the wounds.

- (2) Tourniquets are kept in place, and not released every fifteen minutes as heretofore.

- (3) Antiseptics are no longer recommended for cleansing wounds, just soap and water followed by bandaging.

- (4) All wounds are associated with the possibilities of Tetanus or Lock Jaw and are treated accordingly.

- (5) Treatment for shock comprises keeping the body slightly cool

instead of applying heat. The idea is to maintain body temperature. During the bombing of London with long delay before hospitalization a possibility, the best treatment was found to be  $\frac{1}{2}$  teaspoonful each of table salt and baking soda to a quart of water. Give as much as they can imbibe every fifteen minutes is recommended by the ARC when there is a delay in getting a doctor.

(6) The universal antidote for oral poisoning which is advised is tea, burnt toast and milk of magnesia.

(7) Dry dressings alone are recommended for thermal burns, with no topical medication.

(8) Unconscious conditions are considered under two categories depending on whether breathing is adequate or inadequate, no longer under red, white and blue.

(9) To move an injured patient, pull along the entire axis of the body, don't roll or move the patient from the side, placing blanket under a patient starting at the head and working down to the feet.

(10) In treating frost bite warm water, temperature 90-100 Degrees F, is advised.

(11) In the simplified ARC standard course common emergencies are limited to (a) heart attack, (b) apoplexy, (c) fainting, (d) epileptic fits, (e) unconsciousness, (f) foreign bodies in the eye, air and food passages.

(12) New sections include (a) mental disturbances, (b) intoxication, (c) insulin reaction. Anatomy and Physiology, special wounds, etc., are dealt with in the advanced course.

On the basis of our experience, it would be true to say that students respond favorably to the program. Considerable confusion was precipitated by the many new and radical changes in the skills used by the first-aider.

Often it was difficult to separate truth from hearsay in the empirical evidence offered during class discussion. It is quite possible to better facilitate an understanding of some principles of human physiology and anatomy via a study of first aid. A film from the state department of health effectively climaxes the program.

With such a program, it is possible that our students will be better prepared to cope with whatever the somewhat ominous missile future may offer, as well as surviving in the accident prone present.

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#### BISON AND CATTLE CROSSED, NEW HARDY BREED PRODUCED

By hybridizing the buffalo, which once dominated the western plains of America, with domestic beef cattle, Canadian animal breeders have produced a new kind of animal that promises to be of some use on the upland open ranges of western and northwestern Canada.

## Paper Chromatography for the Secondary Schools

### I. The Analysis of the Common Cations

John G. Surak and Sr. Mary Lucilda, OSF\*

*Marquette University, Milwaukee 3, Wisconsin*

The increasing number of scientific papers published annually involving the use of paper chromatography attests the importance which this technique has attained in chemical research and analysis. As a consequence, the technique of paper chromatography warrants introduction as laboratory exercises in the curriculum of the high school student. These exercises will be found to be quite stimulating and challenging to the pupil. Herewith are described experiments utilizing the simple circular or radial chromatographic technique of Brown (5) and Rutter (6) which has been extended by other investigators (7-16). This technique is easily mastered and the results obtained can be readily interpreted by the method of direct comparison to a "known" which is run simultaneously with the sample being investigated (14).

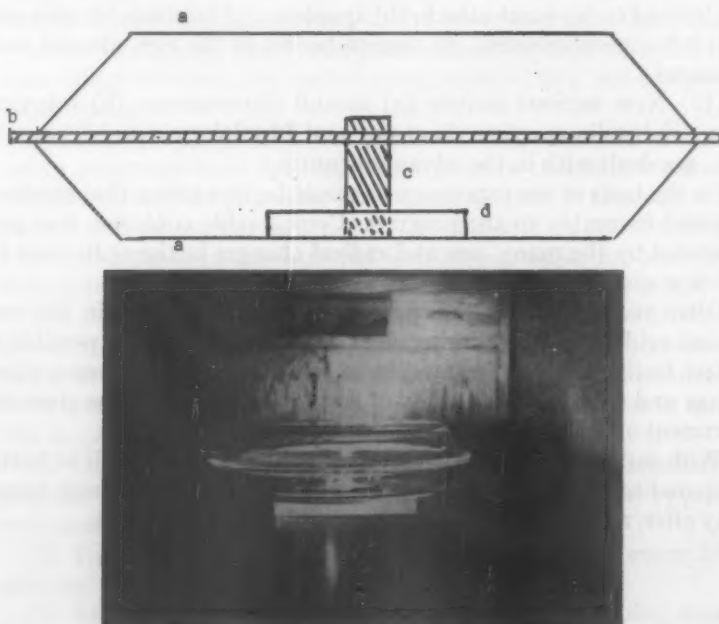


FIG. 1. Arrangement for circular paper chromatography. a. Pyrex pie plate; b. Circular filter paper; c. Wick-feed; d. Solvent container.

\* Present address: St. Mary's Academy, Milwaukee, Wisconsin.

The equipment which we used is simple, inexpensive and readily procurable. The chromatographic chamber consists of a pair of 10-inch diameter pyrex pie plates. See Fig. 1. The edges of the pie plates are ground to fit each other by rotating the plates over a piece of window glass on which there is placed an abrasive suspension of #00 carborundum powder (or some other grinding compound) in glycerine. A plastic cap from a reagent bottle or a 3-inch petri dish is used as a solvent container. Whatman #3MM filter paper discs, 27 cm. in diameter, are used (19, 20). The central feed system consists of a wick which is inserted into a one-cm. slit cut into the center of the filter disc. The wick is made from a 1×10 cm. strip of filter paper which is folded at half its length. The folded end is inserted into the slit and the two tails of the wick dip into the developing solvent. The cations and mixtures to be analyzed are prepared by dissolving a salt of the desired cation in water (5% w/v aqueous solutions).

Literature lists many solvent systems which have been used successfully to resolve the common cations (1, 2, 3, 4, 15). Some investigators follow the conventional qualitative analytical schemes; while others have classified the cations into chromatographic groups based upon the separation of these cations by means of selective solvents (1, 7). Since most chemistry instructors are more familiar with the classification of the cations according to the conventional sulfide qualitative analytical scheme, solvent systems which will successfully separate the cations of Groups I, II, and III are presented in Tables 1-5 (15).

To reveal the resolved cations, chromogenic reagents should be used which will form colored precipitates or colored complexes with them (Tables 1-5). The following techniques can be used: (1) spraying with the aid of an atomizer (2) brushing on the reagent with a camel's hair brush (3) immersing the entire filter paper disc into a dilute solution of the chromogenic reagent and (4) using the "wick feed" method. The resolved zones sometimes become diffused or smeared when using the brush, immersion, and the spray techniques; care should be taken when using them. The "wick feed" method minimizes this tendency. However, it can be used only when ever a single reagent can be used to reveal the resolved cations. In this method the developing solvent, which was in the solvent container, is replaced by the chromogenic reagent; the remainder of the procedure is the same as that used in the developing of the chromatogram.

#### PROCEDURE

1. Mark on each side of the filter paper disc 4 or 8 equidistant diameters.

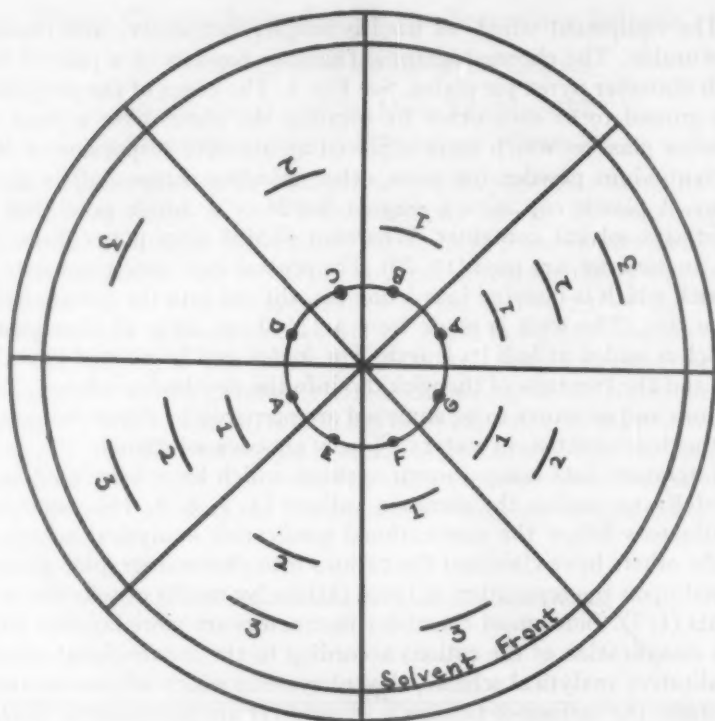


FIG. 2. Filter disc. Showing preparation and spotting technique and direct positional comparison of unknowns and knowns. *A, B, C, D* are known solutions. *E, F, G* are unknown solutions.

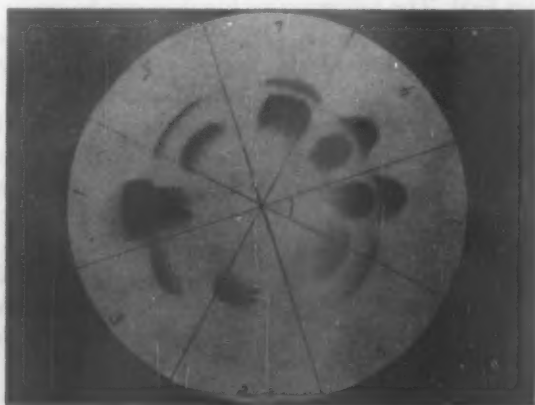


FIG. 2. Results of a copper-nickel alloy run with standards. 1. Nickel coinage; 2. Nickel solution; 3. Copper solution; 4. German silver; 5. Copper-nickel solution; 6. Monel metal.

2. Draw a one-inch diameter circle on each side of the filter paper disc.
3. Cut a one-cm slit in the center of the paper for the wick.
4. Lay the filter paper disc on a clean toweling paper.
5. Make a small indentation with a pencil point on the one-inch diameter circle, midway between the segments formed by the equidistant diameters. See Fig. 2.
6. Turn the paper over, and spot on the raised point of the paper a droplet of about 0.01 ml of the solution to be analyzed with the orifice of a micro capillary tube (or micropipet) containing the solution (17). Knowns should be spotted in different positions on the same filter paper.
7. Permit the droplets to *dry* thoroughly in an atmosphere free of hydrogen sulfide to prevent precipitation of the cations. If it is necessary to increase the concentration of the droplet repeated spottings can be done on these raised points between dryings.
8. Pour 10 mls of the desired developing solvent into the solvent container which was placed in the bottom of the pyrex pie plate.
9. Insert the prepared wick into the slit in the filter disc from the side opposite the raised points.
10. Position the filter disc on the pyrex pie plate in such a manner that the two tails of the wick are immersed in the solvent. See Fig. 1.
11. Invert the other pyrex pie plate over the top of the filter disc as a cover for the purpose of keeping constant the atmospheric conditions within the chromatographic chamber.
12. Remove the filter disc when the solvent front has reached to within 1 to 2 cm of the rim of the pyrex dish.
13. Air dry the filter disc by suspending it from a line with plastic clothes pins. Atmosphere must be free from hydrogen sulfide.
14. Reveal the resolved cations by means of a suitable chromogenic reagent by one of the techniques previously mentioned.
15. Measure the  $R_{fc}$ 's. Identify the unknowns by comparing the positions of the unknown with the known cations which were run simultaneously with it.

#### DISCUSSION

The method of direct positional comparison of unknown substances with knowns which are run simultaneously with it is a simple method of identification. The  $R_{fc}$  value, which is the ratio of the distance from the initial spot to the center of gravity of each zone to the distance from the initial spot to the solvent front, is dependent upon various factors such as: the grade and quality of paper used, the temperature, pH, solvent system used, length of development, humidity, etc. (1, 2, 6, 15, 18). Hence, these values as published in

literature are empirical and can be duplicated only if all the specified conditions in the experiment are fulfilled.

Circular paper chromatography is a rapid method of analysis and can be performed within the time generally allotted to a laboratory period. The experiments are very simple and can be carried out even by the most inexperienced person. Chromatography is strictly an empirical science, that is, it lends itself to modifications. The experimenter is encouraged to improve his results by trying other solvent systems, papers, equipment and techniques.

For additional information on chromatography the science library should have some of the following suggested books:

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TABLE 1  
TYPICAL ANALYSIS—SILVER GROUP  
Group I

Cations: Ag, Hg, Pb (Concentration—as nitrates 5% W/V).

Filter paper: Whatman No. 3MM.

Development time: 3-4 hours.

Developing Solvent: 40% tertiary butyl alcohol  
(volume %)

40% acetone

12% water

8% concentrated nitric acid

Chromogenic reagent: Hydrogen sulfide sprayed on as a solution or absorbed when the filter disc, moistened with water, is held over vapors of hydrogen sulfide.

Cations	Colors of revealed cation-sulfide	Relative R <sub>f</sub> c values
Ag <sup>+</sup>	Black	0.25
Hg <sub>2</sub> <sup>2+</sup>	Black	0.00
Hg <sup>2+</sup>	Tan	0.81
Pb <sup>2+</sup>	Brown	0.50

TABLE 2

## TYPICAL ANALYSIS

## Group II A

Cations: Pb, Cd, Cu, Bi, Hg (Concentration—as nitrates 5% W/V)

Filter paper: Whatman No. 3MM

Development time: 2-3 hours

Developing Solvent: 40% tertiary butyl alcohol  
(volume %)

40% acetone  
 11% water  
 4.5% nitric acid (6N)  
 4.5% acetyl acetone

Chromogenic reagent: Hydrogen sulfide sprayed on as a solution or absorbed when the filter disc, moistened with water, is held over vapors of hydrogen sulfide.

Cations	Colors of revealed cations-sulfide	Relative R <sub>f</sub> c value
Pb <sup>2+</sup>	Black	0.15
Cd <sup>2+</sup>	Yellow	0.32
Cu <sup>2+</sup>	Dark brown	0.40
Bi <sup>3+</sup>	Brown	0.76
Hg <sup>2+</sup>	Tan	0.90

TABLE 3

## TYPICAL ANALYSIS—ARSENIC GROUP

## Group II B

Cations: Sb, As, Sn (Concentration—as nitrates 5% W/V)

Filter paper: Whatman No. 3MM

Development time: 2-3 hours

Developing solvent: 45% tertiary butyl alcohol  
(volume %)

45% chloroform  
 8% hydrochloric acid (8N)  
 2% acetyl acetone

Chromogenic reagent: Hydrogen sulfide sprayed on as a solution or absorbed when the filter disc, moistened with water, is held over vapors of hydrogen sulfide.

Cations	Colors of revealed cations-sulfide	Relative Rfc value
Sb <sup>3+</sup>	Red-orange	0.85
As <sup>3+</sup>	Yellow	0.64
Sn <sup>2+</sup>	Tan	1.0

TABLE 4  
TYPICAL ANALYSIS—ALUMINUM GROUP  
Group III A

Cations: Al and Zn (Concentration—as nitrates 5% W/V)

Filter paper: Whatman No. 3MM

Development time: 6-7 hours

Developing Solvent: 40% tertiary butyl alcohol  
(volume %)

40% acetone

20% hydrochloric acid (3N)

Chromogenic reagent: Two per cent solution of alizarin in alcohol by the wick-feed method.

Cations	Colors of revealed cation	Relative Rfc value
Al <sup>3+</sup>	Red	0.55
Zn <sup>2+</sup>	Violet	1.00

TABLE 5  
TYPICAL ANALYSIS—IRON GROUP  
Group III B

Cations: Ni, Mn, Co, Fe (Concentration—as nitrates 5% W/V)

Filter paper: Whatman No. 3MM

Development time: 1-2 hours

Developing Solvent: 90% acetone  
10% hydrochloric acid (6N)

Chromogenic reagent: Ammoniacal dimethyl glyoxime.

Cations	Colors of revealed cations	Relative Rfc value
Ni <sup>2+</sup>	Red	0.25
Mn <sup>2+</sup>	Red-brown	0.35
Co <sup>2+</sup>	Dark-brown	0.65
Fe <sup>2+</sup>	Brown	1.00

#### FISHING EXPERTS DISCUSS HOW TO FARM FOR FISH

More food can be produced from water per surface acre than from the best farm land. Making the most of the crop grown in lakes, rivers and oceans—million of pounds of fish—can result in big returns to industry as well as fishermen.

## A Chem. Quiz. Board

Ralph E. Dunbar

*North Dakota State College, Fargo, North Dakota*

Perhaps the idea of matching related facts is not new to many areas of instruction. In fact numerous suggestions have been published (1-13) from time to time for improved instruction in chemistry that involves the game or contest instinct. But it does not appear that the ideas involved in the present "Chem. Quiz. Board" have been previously published or that the principles have been employed in science or chemical teaching. No extravagant claim is made for the effectiveness of this device as a teaching tool, as compared to other traditional methods or techniques. It may even be argued that this is just another gadget to amuse indolent and indifferent students. However, it can be stated, and experience has demonstrated, that such a tool will stimulate considerable interest and activity on the part of most students in any average chemistry class.



The "Chem. Quiz. Board" is constructed primarily of a piece of plywood board that is approximately two by three feet in dimension. The size may be varied, either larger or smaller, depending upon the demand of classroom, complexity desired, or use to be made of the same. The lower nine-tenths of the plywood board is systematically covered with large metal label holders. These should be arranged in compact horizontal rows, preferably with an even number of holders in each row. The back side of this same plywood board is wired with a 110 volt A.C. cord and plug that can be attached to any convenient outlet. The 110 volt current is then attached directly to the appropriate terminals of a small 6 volt bell ringing transformer. The resulting 6 volt current is then connected in series to a small buzzer or bell and two flexible leads and contact points that project from the face of the equipment. The metal label holders are connected together by two's at random by insulated leads across the back of the panel. Contact can be made through to the front if small bolts are used to attach the label holders rather than small screws. One-half as many pairs of connected label holders can obviously be arranged as there are total label holders on the entire face of the board. It is extremely important to arrange a complicated and random pairing of these label holders so that students will not subsequently detect a set pattern. Again the pairings can be changed at any subsequent time by a shift in the wiring on the back. Once the pairings have been established it is necessary for the instructor to retain a key to the same, or this can be conveniently recalled by placing like numbers in inconspicuous positions near the several plates. A small 6 volt Christmas tree light may be substituted for the buzzer or bell. In fact both may be built into the apparatus by providing suitable small switches in each circuit. When the wiring is complete a more permanent and attractive arrangement can be provided by inclosing the back with another equal sized piece of plywood, and using small wooden cleats around all edges to give adequate clearance and support.

When the "Chem. Quiz. Board" is completed, appropriate size cards are placed in each of the label holders. The apparatus is plugged into a source of 110 volt A.C. current. All connections and contacts should be checked. The circuit in each case is completed by bringing the contact points on the flexible leads into intimate contact with the metal on the pairs of connected label holders, one contact to each holder. The buzzer or light immediately responds. It should be noted that all exposed conducting surfaces are of the low-voltage, low-ampere type. Once completed related items of chemical information are placed on cards and inserted into connected label holders.

This teaching tool may be used during recitation periods to test a student's knowledge or for drill purposes. In the laboratory it pro-

vides a pleasant and instructive pastime. It lends itself well to museum practices. If made generally available to all corners around the school, it may stimulate considerably interest in the subject under consideration. Its use is not necessarily limited to any particular grade level or type of science instruction. A few suggested uses may involve drill or testing of the following types of related chemical information. It is recommended that the cards be changed frequently. It is even suggested that each member of a class be permitted to prepare an appropriate number of paired cards.

Chemical names and formulas.  
Chemical elements and symbols.  
Chemical elements and atomic weights.  
Chemical elements and atomic numbers.  
Elements and their valencies.  
Pairing of appropriate anions and cations.  
Industrial processes and discoverers.  
Relative volumes of reacting gases.  
Chemical elements and equivalent weights.  
Numerical answers to mathematical problems.  
Physical properties of substances.  
Chemical properties of elements.  
Chemical properties of compounds.  
Association of chemical laws and facts.  
Physical constants and terminology.  
Prominent chemists and areas of specialization.  
Named organic reactions and examples.  
Orientation in the benzene nucleus.  
Chemical journals and related facts.  
Organic names and formulas.

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7. W. E. CALDWELL, "Games for a Chemists' Party," *J. Chem. Educ.*, **12**, 393 (1935).
8. C. LOUISE, "Kem-Check," *J. Chem. Educ.*, **20**, 27 (1943).
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## Problem Department

Conducted by Margaret F. Willerding

*San Diego State College, San Diego, Calif.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution as on the following pages.*

*The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.*

### SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.
2. Drawings in India ink should be on a separate page from the solution.
3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.
4. In general when several solutions are correct, the one submitted in the best form will be used.

### LATE SOLUTIONS

2583, 2618, 2620, 2621, 2622, 2624, 2625, 2628. *Walter R. Talbot, Jefferson City, Mo.*

2625. *C. W. Trigg, Los Angeles, Calif.*

2625. *K. S. Narayanan, Madras, India.*

2624. *J. Byers King, Denton, Md.*

2610. *Thomas E. Collyer, London, England.*

2629. *Proposed by C. N. Mills, Sioux Falls College, S. D.*

Given  $f(x) = ax^2 + bx + c$  and  $g(x) = cx^2 + bx + a$ . Show that  $f(x)$  and  $g(x)$  have a common linear factor when  $(a+c) = \pm b$ .

*Solution by C. W. Trigg, Los Angeles City College*

If  $f(x)$  and  $g(x)$  have a common linear factor, it is also a factor of

$$f(x) - g(x) = (a-c)x^2 - (a-c) = (a-c)(x+1)(x-1).$$

If the factor is  $x+1$ , then by the factor theorem,

$$a(-1)^2 + b(-1) + c = 0.$$

That is,  $a+c=b$ .

If the factor is  $x-1$ , then  $a+c=-b$ .

Solutions were also offered by Doris E. Helms, Hellertown, Pa.; Joseph Kennedy, Bloomington, Ind.; J. Byers King, Denton, Md.; Michael Kornitzky, Milwaukee, Wis.; J. W. Lindsey, Amarillo, Texas; Alice Stoddard, Vicksburg, Miss.; Jacob Street, Oswego, N. Y.; Walter R. Talbot, Jefferson City, Mo.; Alan Wayne, Baldwin, N. Y.; and the proposer.

2630. Proposed by James H. Means, Austin, Texas.

If  $m$  and  $n$  are positive integers, show that

$$mn(m^2 - n^2)$$

has 0, 4, or 6 as its units digit.

*Solution by Brother Felix John, Philadelphia, Pa.*

Write the given expression as  $N = mn(m+n)(m-n)$

- a) If  $m$  and  $n$  are both even,  $(m+n)$  and  $(m-n)$  are also even, and  $N$  is at least a multiple of 16. Hence,  $N$  can have either 0, 4, or 6 as its units digit.
  - b) If  $m$  and  $n$  are both odd,  $(m+n)$  and  $(m-n)$  are both even; hence,  $N$  is a multiple of 4. Therefore, its units digit can be 0, or 4, or 6.
  - c) If  $m$  is even and  $n$  is odd,  $mn$  is even, but  $(m+n)$  and  $(m-n)$  are both odd; hence,  $N$  is at least a multiple of 2. Therefore, its units digit can be 0, or 4, or 6.
1. If  $m$  ends in 9 and
    - a)  $n$  ends in 9,  $mn$  ends in 1,  $(m+n)$  in 8, and  $(m-n)$  in 0. Hence,  $N$  will end in 0.
    - b)  $n$  ends in 8,  $mn$  ends in 2,  $(m+n)$  in 7, and  $(m-n)$  in 1. Hence,  $N$  will end in 4.
    - c)  $n$  ends in 7,  $mn$  ends in 3,  $(m+n)$  in 6, and  $(m-n)$  in 2. Hence,  $N$  will end in 6.
    - d)  $n$  ends in 6,  $mn$  ends in 4,  $(m+n)$  in 5, and  $(m-n)$  in 3. Hence,  $N$  will end in 0.
    - e)  $n$  ends in 5,  $mn$  ends in 5,  $(m+n)$  in 4, and  $(m-n)$  in 4. Hence,  $N$  will end in 0.
    - f)  $n$  ends in 4,  $mn$  ends in 6,  $(m+n)$  in 3, and  $(m-n)$  in 5. Hence,  $N$  will end in 0.
    - g)  $n$  ends in 3,  $mn$  ends in 7,  $(m+n)$  in 2, and  $(m-n)$  in 6. Hence,  $N$  will end in 4.
    - h)  $n$  ends in 2,  $mn$  ends in 8,  $(m+n)$  in 1, and  $(m-n)$  in 7. Hence,  $N$  will end in 6.
    - i)  $n$  ends in 1,  $mn$  ends in 9,  $(m+n)$  in 0, and  $(m-n)$  in 8. Hence,  $N$  will end in 0.
  2. If  $m$  ends in 8 and
    - a)  $n$  ends in 8,  $mn$  ends in 4,  $(m+n)$  in 6, and  $(m-n)$  in 0. Hence,  $N$  will end in 0.
    - b)  $n$  ends in 7,  $mn$  ends in 6,  $(m+n)$  in 5, and  $(m-n)$  in 1. Hence,  $N$  will end in 0.
    - c)  $n$  ends in 6,  $mn$  ends in 8,  $(m+n)$  in 4, and  $(m-n)$  in 2. Hence,  $N$  will end in 4.
    - d)  $n$  ends in 5,  $mn$  ends in 0. Therefore,  $N$  ends in 0.
    - e)  $n$  ends in 4,  $mn$  ends in 2,  $(m+n)$  in 2, and  $(m-n)$  in 4. Hence,  $N$  will end in 6.
    - f)  $n$  ends in 3,  $mn$  ends in 4,  $(m+n)$  in 1, and  $(m-n)$  in 5. Hence,  $N$  will end in 0.
    - g)  $n$  ends in 2,  $mn$  ends in 6,  $(m+n)$  in 0, and  $(m-n)$  in 6. Hence,  $N$  will end in 0.
    - h)  $n$  ends in 1,  $mn$  ends in 8,  $(m+n)$  in 9, and  $(m-n)$  in 7. Hence,  $N$  will end in 4.
  3. If  $m$  ends in 7 and
    - a)  $n$  ends in 7,  $mn$  ends in 9,  $(m+n)$  in 6, and  $(m-n)$  in 0. Hence,  $N$  will end in 0.
    - b)  $n$  ends in 6,  $mn$  ends in 2,  $(m+n)$  in 3, and  $(m-n)$  in 1. Hence,  $N$  will end in 6.

- c)  $n$  ends in 5,  $mn$  ends in 5,  $(m+n)$  in 2, and  $(m-n)$  in 2. Hence,  $N$  will end in 0.
- d)  $n$  ends in 4,  $mn$  ends in 8,  $(m+n)$  in 1, and  $(m-n)$  in 3. Hence,  $N$  will end in 4.
- e)  $n$  ends in 3,  $mn$  ends in 1,  $(m+n)$  in 0, and  $(m-n)$  in 4. Hence,  $N$  will end in 0.
- f)  $n$  ends in 2,  $mn$  ends in 4,  $(m+n)$  in 9, and  $(m-n)$  in 5. Hence,  $N$  will end in 0.
- g)  $n$  ends in 1,  $mn$  ends in 7,  $(m+n)$  in 8, and  $(m-n)$  in 6. Hence,  $N$  will end in 6.
4. If  $m$  ends in 6 and
- a)  $n$  ends in 6,  $mn$  ends in 6,  $(m+n)$  in 2, and  $(m-n)$  in 0. Hence,  $N$  will end in 0.
- b)  $n$  ends in 5,  $mn$  ends in 0,  $(m+n)$  in 1, and  $(m-n)$  in 1. Hence,  $N$  will end in 0.
- c)  $n$  ends in 4,  $mn$  ends in 4,  $(m+n)$  in 0, and  $(m-n)$  in 2. Hence,  $N$  will end in 0.
- d)  $n$  ends in 3,  $mn$  ends in 8,  $(m+n)$  in 9, and  $(m-n)$  in 3. Hence,  $N$  will end in 6.
- e)  $n$  ends in 2,  $mn$  ends in 2,  $(m+n)$  in 8, and  $(m-n)$  in 4. Hence,  $N$  will end in 4.
- f)  $n$  ends in 1,  $mn$  ends in 6,  $(m+n)$  in 7, and  $(m-n)$  in 5. Hence,  $N$  will end in 0.
5. If  $m$  ends in 5 and
- a)  $n$  ends in 5,  $mn$  ends in 5,  $(m+n)$  in 0, and  $(m-n)$  in 0. Hence,  $N$  will end in 0.
- b)  $n$  ends in 4,  $mn$  ends in 0,  $(m+n)$  in 9, and  $(m-n)$  in 1. Hence,  $N$  will end in 0.
- c)  $n$  ends in 3,  $mn$  ends in 5,  $(m+n)$  in 8, and  $(m-n)$  in 2. Hence,  $N$  will end in 0.
- d)  $n$  ends in 2,  $mn$  ends in 0,  $(m+n)$  in 7, and  $(m-n)$  in 3. Hence,  $N$  will end in 0.
- e)  $n$  ends in 1,  $mn$  ends in 5,  $(m+n)$  in 6, and  $(m-n)$  in 4. Hence,  $N$  will end in 0.
6. If  $m$  ends in 4 and
- a)  $n$  ends in 4,  $mn$  ends in 6,  $(m+n)$  in 8, and  $(m-n)$  in 0. Hence,  $N$  will end in 0.
- b)  $n$  ends in 3,  $mn$  ends in 2,  $(m+n)$  in 7, and  $(m-n)$  in 1. Hence,  $N$  will end in 4.
- c)  $n$  ends in 2,  $mn$  ends in 8,  $(m+n)$  in 6, and  $(m-n)$  in 2. Hence,  $N$  will end in 6.
- d)  $n$  ends in 1,  $mn$  ends in 4,  $(m+n)$  in 5, and  $(m-n)$  in 3. Hence,  $N$  will end in 0.
7. If  $m$  ends in 3 and
- a)  $n$  ends in 3,  $mn$  ends in 9,  $(m+n)$  in 6, and  $(m-n)$  in 0. Hence,  $N$  will end in 0.
- b)  $n$  ends in 2,  $mn$  ends in 6,  $(m+n)$  in 5, and  $(m-n)$  in 1. Hence,  $N$  will end in 0.
- c)  $n$  ends in 1,  $mn$  ends in 3,  $(m+n)$  in 4, and  $(m-n)$  in 2. Hence,  $N$  will end in 4.
8. If  $m$  ends in 2 and
- a)  $n$  ends in 2,  $mn$  ends in 4,  $(m+n)$  ends in 4, and  $(m-n)$  in 0. Hence,  $N$  will end in 0.

- b)  $n$  ends in 1,  $mn$  ends in 2,  $(m+n)$  ends in 3, and  $(m-n)$  ends in 1. Hence,  $N$  will end in 6.

Solutions were also offered by J. Byers King, Denton, Md.; Warren Rufus Smith, Passe a Grille Beach, Fla.; Alan Wayne, Brooklyn, N. Y.; and Dale Woods, Stillwater, Okla.

**2631. Proposed by C. W. Trigg, Los Angeles City College.**

The lengths in inches of the edges of three cubes are consecutive odd integers. When piled on a floor, one on top of the other, with edges parallel, the area of the exposed surface is 1,229 sq. in. Find the edges and the order of piling.

*Solution by J. W. Lindsey, Amarillo, Texas.*

Let

$e$  = the length in inches of the edge of the smallest cube.

$e+2$  = the length in inches of the edge of the larger cube.

$e+4$  = the length in inches of the edge of the largest cube.

$18e^2+72e+120$  = the total surface area of the three cubes.

$5e^2+4e+4$  = the unexposed surface area of the three cubes when they are piled on the floor in the following order: the larger first; the smallest second; and the largest third.

The area of the unexposed surface subtracted from the total surface area gives  $13e^2+62e+116$ . Equating, gives  $13e^2+68e+116=1,229$ . (1) Solving quadratic (1) gives  $e=7$ , edge of smallest cube in inches.  $e+2=9$ , edge of larger cube in inches.  $e+4=11$ , the edge of the largest cube in inches. Hence the edges of the three cubes are 7, 9, and 11 respectively.

Solutions were also offered by Hermann Boeckmann, Bloomington, Ill.; Doris Helms, Hellertown, Pa.; Felix John, Philadelphia, Pa.; Joseph Kennedy, Bloomington, Ill.; J. Byers King, Denton, Md.; H. R. Leifer, Pittsburgh, Pa.; Francis L. Miksa, Aurora, Ill.; Warren Rufus Smith, Lake Leeanau, Mich.; and Walter R. Talbot, Jefferson City, Mo.

**2632. Proposed by A. R. Haynes, Tacoma, Wash.**

The normals at three points  $P$ ,  $Q$ ,  $R$  of a parabola meet in the point  $O$ . Prove that

$$SP+SQ+SR+SA=2(OM)$$

where  $S$  is the focus and  $OM$  the perpendicular from  $O$  on the tangent at the vertex.

*Solution by Sister M. Stephanie, Georgian Court College, Lakewood, N. J.*

(Note:  $SA$  is not described. It must be the distance from the focus to the vertex  $A$ .)

$$SP=\sqrt{(x_1-a)^2+y_1^2},$$

where

$$S=(a, 0) \text{ and } P=(x_1, y_1).$$

Let the equation of the parabola be  $y^2=4ax$ . Then  $x_1=y_1^2/4a$ .  $SP$  is then

$$\sqrt{(y_1^2/4a-a)^2+y_1^2}$$

or

$$\frac{y_1^2+4a^2}{4a}$$

$SQ$  and  $SR$  are found in a similar manner;  $SA$  is  $a$ . Letting point  $O$  be  $(h, k)$ , and adding, we have:

$$\frac{y_1^2 + y_2^2 + y_3^2 + 12a^2}{4a} + a = 2h. \quad (1)$$

If three normals to a parabola intersect in  $(h, k)$ , then the ordinates of their points of intersection with the parabola are roots of

$$y^3 + 4a(2a - h)y - 8a^2k = 0.$$

Therefore

$$y_1 + y_2 + y_3 = 0, \quad (y_1 + y_2 + y_3)^2 = 0$$

or

$$y_1^2 + y_2^2 + y_3^2 = -2(y_1y_2 + y_1y_3 + y_2y_3).$$

But

$$y_1y_2 + y_1y_3 + y_2y_3 = 4a(2a - h),$$

and therefore

$$y_1^2 + y_2^2 + y_3^2 = -16a^2 + 8ah.$$

Substituting this value in (1) gives the desired result.

A solution was also offered by the proposer.

**2633. Proposed by A. L. Elliott, San Diego, Calif.**

What are the rational solutions of  $x^y = y^x$  with  $y > x > 0$ ?

*Solution by Walter R. Talbot, Jefferson City, Mo.*

Let  $y = kx$  where  $k > 1$ . Then  $(x^k)^x = (kx)^x$ . Taking  $x$  root of both members gives  $x^k = kx$  or  $x(x^{k-1} - k) = 0$ . Either  $x = 0$ , which is not acceptable, or  $x = k^{1/(k-1)}$ . Now  $x$  is rational if  $k = 2$ ; so  $x = 2$  and  $y = 4$ .

**2634. Proposed by E. M. Edwards, San Diego, Calif.**

A Census Taker recently made some interesting observations: The population of East Jalopy at one time was a perfect square. Later when the population had increased by 100, it was one more than a perfect square. But now, since the population has increased by another 100, it is again a perfect square. What is the present population of East Jalopy?

*Solution by Joseph Kennedy, Bloomington, Ind.*

Let  $x^2$  be the population of East Jalopy "at one time". Then  $x^2 + 100 = k^2 + 1$  and later  $m^2 = k^2 + 101$  or  $m^2 - k^2 = 101$ . This latter expression may be written  $(m - k)(m + k) = 101$ . Since  $m$  and  $k$  are integers and the only integral factors of 101 are 1 and 101 we may write the system:

$$\begin{cases} m - k = 1 \\ m + k = 101 \end{cases} \quad \text{whose solution is} \quad \begin{cases} m = 51 \\ k = 50 \end{cases}.$$

The present population of East Jalopy is  $51^2$  or 2,601.

Solutions were also offered by Leon Bankoff, Los Angeles, Calif.; Hermann Boeckmann, Bloomington, Ill.; Doris Helms, Hellertown, Pa.; J. Byers King, Denton, Md.; John Q. Taylor King, Austin, Texas; Felix John, Philadelphia, Pa.; H. R. Leifer, Pittsburgh, Pa.; J. W. Lindsey, Amarillo, Texas; Warren Rufus Smith, Lake Leelanau, Mich.; Walter R. Talbot, Jefferson City, Mo.; and C. W. Trigg, Los Angeles, Calif.

### STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

**Editor's Note:** For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2624. Larry Clopper, Caroline High School, Denton, Md.  
 2629. William E. Schoknecht, Milwaukee, Wis.  
 2629. Ronald Kurtus, Rufus King High School, Milwaukee, Wis.  
 2634. Edgar Rose, Monroe High School, Rochester, N. Y.  
 2634. Steve Svabk, Caroline High School, Denton, Md.  
 2634. John F. Osinski, Caroline High School, Denton, Md.

### PROBLEMS FOR SOLUTION

2653. Proposed by Alan Wayne, Baldwin, N. Y.

Given two different positive numbers, find the necessary and sufficient condition that their arithmetic mean will be closer in value to their positive geometric mean than will be either of the given numbers.

2654. Proposed by John Nayler, Calgary, Alberta, Canada.

A man working on the surface of a space-ship refuelling craft in the form of a perfect cube is, for safety, tied to an anchor ring by means of a rope equal in length to one edge of the cube. Find the percentage of the total surface area of the craft accessible to the man if the anchor is a) at one corner, or alternatively b) in the center of one face.

2655. Proposed by Brother Felix John, Philadelphia, Pa.

Given the five numbers  $a, b, c, d$  and  $e$ ;  $a, b$ , and  $c$  are in Arithmetic Progression;  $b, c$ , and  $d$  are in Geometric Progression;  $c, d$ , and  $e$  are in Arithmetic Progression;  $ac = 2e$ ;  $2d + e = bc$ . Find the numbers.

2656. Proposed by J. W. Lindsey, Amarillo, Texas.

If the top of a ship's mast is 60 ft. above the sea, how far must the ship sail before it disappears below the horizon? Take the radius of the earth as 4,000 miles.

2657. Proposed by Doris Helms, Hellertown, Pa.

Devise, give an example of, and offer justification for a system of checking addition of numbers written to the base eight by casting out sevens.

2658. Proposed by P. C. Tomljanovic, Tucson, Ariz.

At what point on the known diameter of a coin should the center of a coin (of equal area) be placed such that the covered area is equal to the exposed area?

### NEW ANTIBIOTIC FIGHTS NUMEROUS INFECTIONS, STAPHYLOCOCCUS

A new antibiotic that is active against strains of staphylococcus that other antibiotics do not affect, has been introduced. The antibiotic, kanamycin, is very active against clinical strains of staphylococcus resistant to the commonly used antibiotics, penicillin, streptomycin, the tetracyclines, erythromycin, chloramphenicol and novobiocin, researchers report.

Combinations of kanamycin and penicillin indicate that there is no interference with each other's action and that the two antibiotics are consequently compatible.

## Books and Teaching Aids Received

PRACTICAL CHEMISTRY FOR SCHOOLS, by C. Jenkins, *Head of Science Department, Worthing School for Boys*. Cloth. 222 pages. 14×21.5 cm. 1958. Cambridge University Press, 32 E. 57th Street, New York 22, N. Y. Price \$1.75.

MATHEMATICS IN FUN AND IN EARNEST, by Nathan Altshiller Court. Cloth. 250 pages. 13.5×20 cm. 1958. The Dial Press, Inc., 461 4th Avenue, New York 16, N. Y. Price \$4.75.

THE MEDICAL TECHNOLOGIST, by Lura Street Jackson, Vocational and Professional Monographs Series. Paper. 36 pages. 15×23 cm. 1958. Bellman Publishing Co., Cambridge 38, Massachusetts. Price \$1.00.

SOCIAL WORK, by Margaret E. Adams; Vocational and Professional Monographs Series. Paper. 36 pages. 15×23 cm. 1958. Bellman Publishing Co., Cambridge 38, Mass. Price \$1.00.

INSTRUMENT AND CONTROL ENGINEERING, by Lloyd Slater; Vocational and Professional Monographs Series. Paper. 46 pages. 15×23 cm. 1958. Bellman Publishing Co., Cambridge 38, Mass. Price \$1.00.

STAR '58, A selection from the winning entries in the 1958 Science Teacher Achievement Recognition Program, edited by Abraham Raskin. Paper. 52 pages. 21.5×28 cm. 1958. National Science Teachers Association, 1201 16th Street, N.W., Washington, D. C.

MATHEMATICS, GRADES 9-12, Prepared by the Mathematics Curriculum Committee of the Davenport, Iowa Community School District. Paper. 75 pages. 21.5×28 cm. 1958. Davenport Community Schools, Davenport, Iowa.

PHYSICAL SCIENCE FOR PROGRESS, by Milton O. Pella and Aubrey G. Wood. Cloth. Pages x+515. 1959. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. Price \$4.80.

MATHEMATICS FOR HIGHER NATIONAL CERTIFICATE, Vol. II (Electrical), by S. W. Bell and H. Matley. Cloth. Pages x+486. 13×22 cm. 1958. Cambridge University Press, 32 E. 57th Street, New York 22, N. Y. Price \$6.50.

THE BOOK OF KNOWLEDGE, The Children's Encyclopaedia, E. V. McLoughlin, Ed. Cloth. 20 volumes. 7607 pages. 16.5×24 cm. 1958. The Grolier Society, Inc. New York, N. Y.

MATHEMATICS FOR ENGINEERS, by W. N. Rose. Cloth. Pages xii+403. 13.5×21.5 cm. 1958. Chapman and Hall Publishers, 37 Essex St., London, England. Price 25s.

APPLIED DIFFERENTIAL EQUATIONS, by Murray R. Spiegel, *Professor of Mathematics, Rensselaer Polytechnic Institute*. Cloth. Pages ix+381. 15×23 cm. 1958. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price \$9.00.

LIGHT, by Alexander Efron, *Chairman of Physics Department, Stuyvesant High School, New York*. Paper. Pages vii+127. 14×1.5 cm. 1958. John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y. Price \$2.25.

BASIC PULSES, by I. Gottlieb. Paper. 175 pages. 15×23 cm. 1958. John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y. Price \$3.50.

LIBRARY OF MATHEMATICS, edited by Walter Ledermann. Includes four volumes, as follows: LINEAR EQUATIONS, by P. M. Cohn; SEQUENCES AND SERIES, by J. A. Green, DIFFERENTIAL CALCULUS, by P. J. Hilton, and ELEMENTARY DIFFERENTIAL EQUATIONS AND OPERATORS, by G. E. H. Reuter. Paper. Pages viii+74; viii+78; vii+56; and viii+67. 12×18.5 cm. 1958. The Free Press of Glencoe, Illinois, 119 West Lake Street, Chicago 1, Ill. Price \$1.25 each.

THE WORLD OF SCIENCE, by Jane Werner Watson. Cloth. 216 pages. 20.5×28 cm. 1958. Simon and Schuster, Publishers, 630 Fifth Avenue, New York 20, N. Y. Price \$4.95.

RESEARCH REPORT ON THE ROLE OF PHYSICAL MATURATION IN DETERMINING THE ABILITY OF JUNIOR HIGH SCHOOL BOYS TO PERFORM COMPLEX FINGER COORDINATIVE ACTIVITIES IN INDUSTRIAL ARTS, AND AN INDEX TO LEVEL OF ABILITY, by John A. Fuzak, *Professor of Industrial Education, Michigan State University*. Paper. Pages ii+81. 18×25 cm. The American Technical Society.

INTRODUCING MATHEMATICS, by Floyd F. Helton, *Professor of Mathematics, Central College*. Cloth. Pages xv+396. 15×32 cm. 1958. John Wiley and Sons, Inc., 440 4th Avenue, New York 16, N. Y. Price \$5.75.

AN EMERGING PROGRAM OF SECONDARY SCHOOL MATHEMATICS, by Max Beberman. Cloth. 44 pages. 11×17.5 cm. 1958. Harvard University Press, Cambridge, Mass. Price \$1.50.

BOOKS ON ZOOLOGY, prepared by Ross H. Arnett, Jr., *Catholic University of America*. Paper. 87 pages. 15.5×23 cm. 1958. Society of Systematic Zoology, Department of Zoology, Southern Illinois University, Carbondale, Ill. Free.

THE STRUCTURE OF ARITHMETIC AND ALGEBRA, by May Hickey Maria, *Assistant Professor of Mathematics, Brooklyn College*. Cloth. Pages xiv+294. 15×24 cm. John Wiley and Sons, Inc., 440 4th Avenue, New York 16, N. Y. Price \$5.90.

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## Book Reviews

THE BOOK OF KNOWLEDGE, The Children's Encyclopaedia, E. V. McLoughlin, Ed. Cloth. 20 volumes. 7607 pages. 16.5×24 cm. 1958. The Grolier Society, Inc. New York, N. Y.

A journal such as SCHOOL SCIENCE AND MATHEMATICS must review a book, encyclopaedia or other publication with certain reservations in mind. The clientele tend to be restricted to the specialized fields of science and mathematics. Hence, a review of any publication such as the one cited above must take cognizance of the interests of that clientele, rather than evaluating the publication specifically for the purpose for which it is designed. When *The Book of Knowledge* arrived in the editorial offices it was clear from the beginning that the review would deal chiefly with the question, "Does such a general publication have sufficient material to offer in specialized fields of science and mathematics to warrant recommending it to the readers of SCHOOL SCIENCE AND MATHEMATICS? A second major point to be considered was this. No person sits down and reads an encyclopaedic type of publication as he does a textbook or a novel. Rather he refers to such a document when he needs specific information on a certain subject. This review therefore deals with the question, "Can one find in *The Book of Knowledge* the kind and extent of information suitable for a person who teaches science and mathematics?"

Obviously, in order to answer such a question it is necessary to put such an encyclopaedia into use and determine whether it meets the criteria. The reviewer put the publication into use for a period of about six months. Such use involved searching for reference materials in the production of a book, and checking on scientific data, measurements and constants.

*The Book of Knowledge* consists of 20 volumes, the last being the *Index* volume. It is accompanied by two teaching aids, one entitled "Home and School Study Guide to the Book of Knowledge," and the other "Character Education Guide to the Book of Knowledge." Each volume is about 400 pages long. The feature of the publication is that the topics are not covered alphabetically as in a typical

encyclopaedia. Rather, it is designed as a children's encyclopaedia organized around topics that appear in nearly every volume. Among the topics are The Earth, Wonder Questions, Animal Life, Our Own Life, Familiar Things, All Countries, The United States, The Arts, Literature, The Famous Rocks, Stories, Poetry, Men and Women, and Things to Make and Do. Other areas are, of course, dealt with besides these, and not all areas are covered in every volume.

In general, the *Book of Knowledge* is probably most suitable for children from the third through the eighth grades. Below that level the problem of reading difficulty would be encountered. Above that level, the material is not sufficiently comprehensive or sophisticated. Yet, within those levels it will serve excellently. In fact, the reviewer was able to locate during the trial period all the materials he looked for dealing with science and mathematics at these levels. Many materials ordinarily taught above these levels were also found but were presented in a clear, lucid fashion.

The newer topics of science such as rockets, antibiotics and nuclear energy are covered extensively and well. The reviewer was unable to find any topic that was current at the time of publication that was not included. In general, the more difficult and mature presentations of areas are found in the later volumes.

In the reviewer's opinion the *Book of Knowledge* does the job it should do. The materials for science and mathematics are there and are well covered. The prestige of the contributors should be sufficient validation of the material. Even in days of short finances, the *Book of Knowledge* deserves special consideration. Without doubt its use in a school would improve the teaching of science and mathematics. The reviewer intends to recommend it whenever suggestions for library materials at the levels indicated are requested.

GEORGE G. MALLINSON

INTRODUCTION TO DIFFERENCE EQUATIONS WITH ILLUSTRATIVE EXAMPLES FROM ECONOMICS, PSYCHOLOGY, AND SOCIOLOGY, by Samuel Goldberg, *Associate Professor of Mathematics, Oberlin College*. Cloth. Pages xii+260. 16×23 cm. 1958. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. Price \$6.75.

In the preface the author points out that the text is primarily intended for social scientists who wish to understand basic ideas involved in using difference equations, although he hopes the book will be of value to mathematicians. Technically no mathematical background beyond trigonometry is required (except for a few optional sections which would require calculus); however, some mathematical maturity is suggested. This reviewer feels that the social scientist with the minimum mathematical background will find this book far from easy reading, just as the mathematician without considerable background in economics and other social sciences may need to burn considerable midnight oil before he finishes the book.

The text seems to provide a somewhat rapid introduction to the topic, and in addition may prove an eye-opener to many mathematicians who are not aware of the applications of mathematics in the social sciences. Even if the teacher does not find it suited as a text in a formal course in difference equations, it certainly would be a valuable addition to any university library, either as supplementary material helpful to students in such a course, or as a reference not completely beyond the grasp of a colleague not in the field of pure mathematics. It seemed to this reviewer that the author had been exceptionally successful in achieving clarity of expression.

Cecil B. Read  
University of Wichita  
Wichita, Kan.

CHEMISTRY AND YOU IN THE LABORATORY, by G. M. Bradbury, Martin V. McGill, Herbert R. Smith and Philip S. Baker. Paper. Pages viii+310. 15×21 cm. 1957. Lyons and Carnahan, 2500 Prairie Avenue, Chicago 16, Illinois.

This is a laboratory manual to accompany the popular text "Chemistry and You," by the same authors. This well written laboratory manual consists of eighteen units covering a total of 77 experiments. The entire field of general chemistry is well covered by the 77 experiments. Previous to experiment number one the authors have devoted five illustrated pages to laboratory technique under the general heading "How to Work with Apparatus in the Laboratory." The experiment sheets are of the "fill-in" type which are perforated and thus enables the student to remove each sheet as the experiment is finished and give it to the laboratory instructor.

Fifteen valuable tables dealing with such topics as the metric system, aids in chemical arithmetic, gas laws, and other topics are found on pages 289-305.

By way of general evaluation the reviewer believes that this laboratory manual is well written and the directions should be easy for the students to follow. The authors are commended on the 15 practical experiments dealing with organic chemistry.

GERALD OSBORN  
Western Michigan University  
Kalamazoo, Mich.

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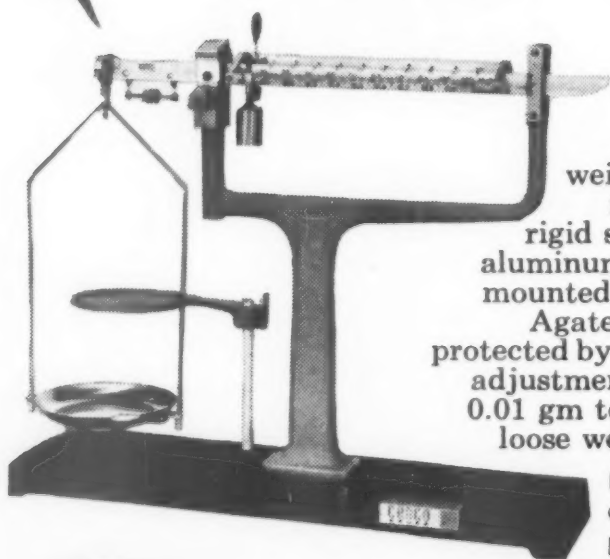
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